BULLETIN

OF THE

Scientific Laboratories

OF

DENISON UNIVERSITY,

EDITED BY

C. L. HERRICK, DEP'T. OF GEOL. AND NAT. HISTORY,

AND

A. D. COLE, DEPARTMENT OF CHEMISTRY AND PHYSICS.

VOL. II, PARTS 1 AND 2.

GRANVILLE, OHIO, MAY, 1887.

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Denison University,

GRANVILLE, OHIO,

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Fall Term begins Wednesday, September 8, 1887.

FOR CATALOGUE AND FURTHER INFORMATION, ADDRESS

GALUSHA ANDERSON, *President.*

GRANVILLE, LICKING CO., OHIO.

XU

BULLETIN

OF THE

SCIENTIFIC LABORATORIES

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VOL. II, PART 1.

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EDITORIAL STATEMENT.

We note with pleasure the growing interest in the work represented by this publication and the greatly increased facilities now afforded for advanced work. The present volume, although the work of more hands than that of last year, does not adequately indicate the scope which the publication is expected to cover, because a disproportionate amount of space has been given to geological discussions, the results of which it is hoped to immediately employ. Several articles again crowded out, as well as the promised instalments of continued papers, will appear in the next issue The department of Chemistry and Physics may be expected to contribute its full quota to the interest of the publication.

We need hardly remind the professional naturalist that other considerations are subordinated to the educational, and the papers are strictly, as they profess to be, outgrowths of class work and laboratory exercise. If, notwithstanding, results of a certain degree of interest as contributions to science develop, it will not be regretted by us. It ought not to be necessary to say that the material is in each case original, and collected, as well as elaborated, by those to whom it is accredited.

The uniform kindness of the learned societies from which exchanges have been solicited, calls for grateful recognition on our part. A full acknowledgement will be found in the next issue.

To kind friends who have contributed apparatus and specimens we can only speak general indebtedness. A freezing microtome manufactured and donated by Dr. Jacobs, of Newark, should be appreciatively mentioned, as also a valuable collection of eggs presented by Mr. G. D. Pearce. Finally, it should be said that the means for sustaining this publication have been secured solely by voluntary con-

tribution, almost the entire amount being donated by Hon. E. J. Barney and Hon. J. B. Thresher, of Dayton, and another person too immediately interested to care to allow his name to appear. The results of the laboratory class on lake Superior, during the last summer, were so satisfactory that it is hoped to repeat the experiment on a larger scale during the summer of 1888. The editors will be glad to correspond with teachers and others desiring such opportunities as would be afforded by laboratory work at a station located upon the Gulf of Mexico. The work will depend somewhat on the desires of those participating, but will consist chiefly in lectures on biology, chemistry, physics, and geology, and laboratory study in these branches, as well as detailed investigation of the peculiar fauna of the Gulf. The co-operation of eminent southern naturalists is assured, and the imperfectly known crystalline rocks of the South will afford a fine field for the lithologist, as the proposed scheme involves a short tour in the mountains of Alabama. The facilities of the college laboratories will be placed at the disposal of the workers so far as may be practicable and all obtainable aids will be secured.

A Sketch of the Geological

HISTORY OF LICKING COUNTY,

Accompanying an Illustrated Catalogue of Carboniferous Fossils from Flint Ridge, Ohio.

Every acre of our earth's surface is marked with tracery which, if patiently studied and correctly interpreted, will supply pages in the history of creation. The mind which has ceased to be interested by the record thus preserved or which inclines to ridicule the youthful enthusiasm which sees in all natural phenomena manifestations of Divine intelligence, must be far forward in its differentiation (or rather indifferent-ization) toward the *Nirvana* of blase' modern scientists.

We believe that there is vast gain every way in supplementing the natural curiosity which furnishes the earliest incentive to investigation by maturer faith in immanent Divinity in nature. Still more useful is it if one feels that the problems afforded by the earthy records are God's gifts to us with the intent that we should learn to know his will concerning the earth as well as ourselves.

This paper is intended to outline briefly those facts in the geological history which lie easily within the reach of any one living in this county, and to afford the means of studying intelligently the portion of the geological column lying exposed in this part of Ohio. In as much, however, as the column is an integer, the investigation of one part is of importance in the study of the rest.

Far too little has as yet been done in the careful and systematic study of limited fields. We need in geology more than elaborate generalizations on insufficient data, carefully elaborated pictures of limited areas and the succession of life traceable in closely related strata. We believe it possible to become almost as familiar with the fauna and flora of Licking county, for instance, during the time when coal deposits were forming as we are with its present animals and plants. The question whether the earth has been repeopled at the opening of each

era, as claimed by some, or gradually reached its present condition by progressive development and continuous differentiation, is most likely to be settled by such detailed study of superposed strata. The work represented by the notes here given has been the recreation of spare moments during less than a year, but has been sufficient to indicate an almost exhaustless mine of interesting information. It is hoped that the study may be pursued much further. The accumulation of material has been greatly facilitated by the co-operation of the class in lithology of 1886, some members of which have continued to assist in the necessary collecting and field-work. Mr. Foerste, of '87, has also rendered efficient aid in collecting and otherwise.

In as much as the study was carried on independently of the published reports it is gratifying to observe the substantial accord of our results with those of the Geological Survey, so far as the latter extend. The examination was restricted to a band some miles in width, extending from Alexandria to Brownsville, with the view of perfecting a geological section across the line of contact between the coal measures and the sub-carboniferous formations, which alone are here represented. Our plan has been to study the various quarries and natural exposures, gathering such information as may be furnished by fossils or stratigraphy, then proceeding to parallelize as far as possible the strata which are recognizable. It is surprising how many hints a barren looking heap of rock may often furnish. The dip of strata is often only obtainable by the use of a transit as it varies little from the horizontal. As we pass from horizon to horizon the imagination sees broad sandy shoals, marked by ripples, and here and there exposing to view bivalves of unfamiliar form, or detached valves of brachiopods. Again a shallow lagoon, with a muddy bottom supporting a luxuriant vegetation of Spirophyton sea-weeds, whose broad leaves floated about like the pond-weeds of to-day. Among these darted the trilobites, springing backward by a quick stroke of the tail, or lazily floating near the surface, or crawling along the under surfaces of their leafy retreats. In clearer spots the sea-lily spread its graceful but direful petals while an occasional horny shielded fish flashed by in pursuit of slow-swimming gasteropods. Here one reads proof of a stormy promontory, where the waves ravened pitilessly about the abutting cliffs, and scattered the eroded material in bars and banks within sheltering coves, or distributed it by currents more equally over a wide area. Such was the condition of Granville and the adjacent townships before it was

raised forever beyond the creative touch of the ocean. The Waverly group of rocks is the result of the quiet but constant efforts of our most modern sea. Farther east, however, the sea still continued, but cut off from direct communication with the western ocean and only now and then keeping up the union at the south. The townships of Madison and Hopewell were covered by shallow lagoons of salt water. It was now a period of quiet. The gradual formation of a ridge of considerable width, along the axis, extending from Cincinnati to Toledo, had cut off the "sou-westers," which had stunted vegetation, land along the borders of the steaming lagoons a dense forest of ferns and succulent vegetation of unfamiliar kinds sprang up. The lepidodendrids, whose trunks had occasionally been preserved in the sandbars of the Waverly sea, gave place to a more dense growth, which literally buried itself under its own profusion and the decaying boughs were soon submerged by the variable, though shallow waters. There were, however, constantly recurring periods when the ocean asserted its ascendency; local or general depressions were followed by invasions of deep arms of the sea, which eroded the distant granite or nearer sand hills and covered all evidences of forest luxuriance with sand. The animals which swarmed in the shallow lagoons were such as are found everywhere in the coal measures and the accompanying plates illustrate the most important species.

The above history is recorded in alternating layers of shale, coal, and white sandstone. In the following diagram the sequence of strata is illustrated, while the sections of Fig. 2 show the chief observed exposures and their relations, as further indicated upon the geological map.

(The section represented in Figure 1, is, in general, east and west, but there is also introduced a partial section from Madison township, which is nearly north and south, exhibiting a greater dip, probably of a local nature, as above indicated. The vertical scale is greatly exaggerated—50 feet vertical, equalling one mile horizontal.)

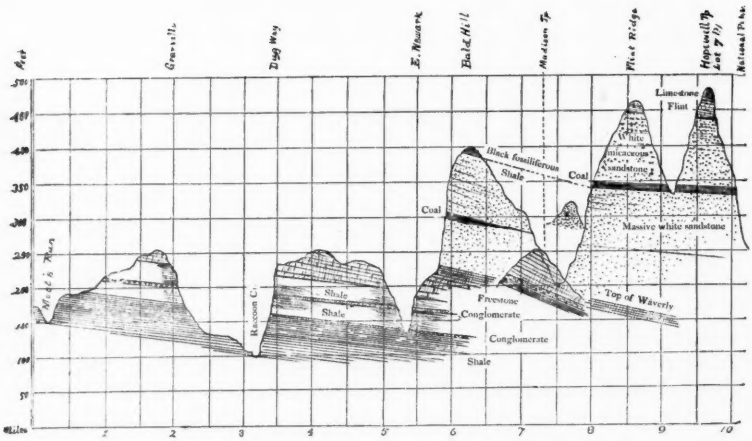

Fig. 1. SECTION FROM MOOT'S RUN TO FLINT RIDGE, LICKING CO., OHIO.

There is nothing to indicate any great disturbance in position in the strata since their deposition. Although there is no obvious unconformity between any of the strata exposed, yet the fact that so many of them are shore deposits and the fact that farther south and east bands of limestone are interpolated, indicates that here and there there must have been intervals of considerable duration when the process of accumulation was interrupted and the days ran round unrecorded. Any attempt to estimate the time represented must include ample allowance for such breaks in the continuity of the series. Within the limits of our study about 400 feet in vertical thickness can be assumed, of which 200 feet consists of the coal measure rocks, and the remainder of shales and freestones of sub-carboniferous age. It is probable that 100 feet should be added below the rocks exposed in this part of the county to touch the dividing line between the Devonian and carboniferous. We have then some 500 feet of material, representing at least, say 500,000 years, without allowance for the intervals.

Much of the material, undoubtedly, accumulated much more rapidly than a foot a century; while the shales and coals no doubt represent periods of slower deposition. Highly carbonated waters and atmosphere no doubt facilitated subaerial erosion, while the profusion of vegetation must have greatly increased the deposit of organic matter.

Altogether, it would seem that modern measures as applied to calculations in the Paleozoic, are likely to be too long rather than too short. Here the question naturally arises, what is the source of all the material thus accumulated, especially the quartz. Most of the white sandstones of the coal measures are highly micaceous and in places the loose sandstone has a schistose character, due to the presence of large amounts of light colored mica. Such deposits can be most readily explained by supposing them more or less directly derived from granite rocks, which were first kaolinized, the aluminous or fedspathic ingredients being separated and floated to a distance, there producing the shales, while the sand is accumulated near the shore line. The mica is partly separated, but is always found in connection with arenaceous deposits. But how is it that such large deposits of sand are found at so great a distance from granitic ranges? To this it might be suggested that many spurs of the Archean continent had remained even near this area and that the material was thus derived directly. Such spurs would, however, be very likely to leave other evidences of their existence. It might be, on the other hand, that during the preceding (Devonian) age, sandstones had been accumulated, which now fell a prey to encroaching and receding seas. But in such a case we might hope to find fragments of the fossils of the Devonian among carboniferous deposits or in other ways receive information of the appropriation, much as the old parchments used for church missials have been forced to reveal the more ancient heathen lore inscribed beneath. Aside from the negative evidence hinted at, we have the fact that there are here and there conglomerates containing quartz-fragments which must in all probability, have been derived from veins such as are found in igneous rocks. A third explanation is that the highlands on the east and north really supplied the materials and that they were floated and rolled to their present positions by tidal and wave action. This theory receives incidental confirmation in several ways. We find the heavier materials collected more considerably to the east, even in as narrow an area as our own. Bands of Waverly rock, which at Granville consist of freestone, become conglomeritic east of Newark. Northeast of Clay Lick there seems to have been a promontory or low spit during the early part of the Waverly epoch. Here accumulated quantities of sand and conglomerate, while to the south and west layers of shale and freestone were formed at the same horizon. Then, as now, the dip was southwest at this point, and in the more protected reach of shore to the

west, there gathered at intervals great floating beds or tangles of sea-weeds. Currents setting from the northeast, bearing freight of sand and gravel, would naturally deposit all but the lighter in making this point, and in the slower eddies beyond drop the clays we really find.

Now it remains to notice that there was evidently a considerable interval between the fossiliferous beds of the upper Waverly and the fossil bearing shales of the coal measures—a far greater interval than is represented by the 170–180 feet intervening. An interval of 100 feet between the shale at Flint Ridge and the silicious limestone seems to have produced no marked change in fauna, many identical species being found, while very few forms pass from the Waverly into the coal measures. This might be partially explained by the changed conditions, but that this is insufficient is indicated by the fact that Waverly freestones contain many species identical with limestones of the same horizon (Spergen Hill) in Indiana. However, it may be in part explained by supposing that the waters during the Waverly epoch were connected with the sea at the west, while during the coal measures period the sea was part of a southeastern basin, which in the meantime had become independent. Nevertheless, we have evidence of a period left unrepresented in Licking county, but which was employed farther south in the formation of sub-carboniferous limestones (Maxville.)

In order to determine the exact relation between the strata mentioned it will be necessary to carefully study and compare all the remains preserved, as well as to carry stratigraphical research beyond the limits assigned. We will examine, therefore, first of all the fossils found in a thin layer of black shale immediately overlying the coal at Flint Ridge and lying about 100 feet below the summit of the ridge. This stratum appears upon the top of Bald Hill, near Newark, with identical fossils and lithological character. It is here not supported by coal, but lies 100 feet above the lowest coal horizon in the county (about 73 feet only above the Waverly). This shale also appears toward Brownsville, wherever its horizon is reached. This is undoubtedly coal measure rock and its fossils are those found in the coal measures of West Virginia, Illinois, Missouri, and the far West. After enumerating these, comparisons may be instituted with the Waverly and sub-carboniferous limestone as well as the silicious limestone above. This narrow band of shale is one of the most highly fossiliferous strata known, though the number of species is not relatively so great.

Should there be found errors of identification, as would be natural where it has frequently been impossible to obtain reliable examples of related forms, and in spite of obvious incompleteness, it is hoped that, in as much as most of the forms described are figured, this catalogue may serve a good purpose in several ways.

The Surface Geology of the southeastern part of Licking county, does not present any very striking points, but it may be interesting to notice a few of the salient features. The drainage is toward the southeast, the tributaries of the Licking river, constituting almost the only streams, except in Bowling Green township. The only large body of water is the reservoir in Union and Licking townships.

Granville township furnishes numerous exposures of the Waverly rock, which here may be separated into an upper massive portion furnishing available freestone for foundations and construction below the water table and for coarse masonry, and the lowest shaly portion which is here and there interrupted by beds of freestone. The quarries are all in the hill tops and may be found in many parts of the township, everywhere, in fact, where the elevation is great enough. But few are worked more than needed for local consumption, but in the vicinity of Granville, especially in the hills lying north of the village, are several which are considerably developed. The best exposure in the township is midway between Granville and Newark and is formed by the erosion of Raccoon creek. The section at this place is a typical one and exposes all rocks found in the township, except a few feet above. About 150 feet is therefore the approximate vertical measure for the township. The upper courses are in places very fossiliferous, Crenipecten Winchelli being a characteristic fossil. Below it is a layer of shale characterized by the plant Spirophyton, and below this an 18-inch band of conglomerate. A few feet below the conglomerate is a dark shale, affording many lamellibranchs, Allorisma hannibalensis being abundant. The free-stone below is apt to be full of a species of Camerophoria and many other fossils. The lower shales are usually barren of other fossils than the stems of fucoids. At Spring Valley, a beautiful dell a half mile southwest of Granville, a good exposure of the shale may be seen which is, however, much surpassed at Moot's Run, nearer to Alexandria. Union township lies almost wholly below the free stone, though several exposures of the shale may be found along the streams. This shale is in many places highly concretionary, the nodules often containing plant or animal remains. At Moot's run, some

interesting Producti have been found imbedded in these concretions. Northeast of Granville is a very rough section of the county and here the conglomerate is more highly developed than elsewhere, and is often highly fossiliferous, Chonetes illinoisensis, Spirifer carteri, and two other species, as well as large specimens of Hemipronites being the characteristic fossils. The highest hills in this vicinity are perhaps 150 feet above the altitude of the conglomerate, at the "dug way," and may be near the line of juncture with the coal-measure sandstone or, indeed, may contain a few feet of that rock, though only surface fragments of such a rock have been seen. The thickness of the conglomerate or coarse Waverly sandstone is estimated at twenty feet and graduates insensibly into the olive free-stone, as well shown a half mile northeast of the "dug way," half way from Granville to Newark. The free-stone extends in these hills to some 120 feet above their bases, (or perhaps 60-80 feet above the 18-inch layer of conglomerate, this being a mere estimate). The dip is here very slight, probably southeast.

Hebron Hill, south of Granville, is 106 feet above the B. & O. track, south of it. South of Newark, along the right bank of South Fork of Licking, are many exposures of the Waverly rock. The abutment of the bridge crossing this stream, west of Mechanicsburg, is 170 feet lower than the top of Hebron Hill and about 60 feet below the B. & O. track, as indicated. The hills east of the bridge rise, 180 feet and do not reach the coal-measure sandstone. The village of Mechanicsburg is 150 feet above the abutments, but a few rods east, at the Licking township line, are hills over 200 feet high, with thirty to forty feet of the characteristic white sandstone and conglomerate. It is here massive and might be quarried with ease. A few rods northeast is a high hill, 300 feet above the bridge, where there seemed to be about 115 feet of coal-measure rock, part of which is a ferrugineous shale, and extends far above the horizon of the Bald Hill coal. Indeed, some indications of its presence could be detected. The summit of this hill is some 60 feet higher than the horizon of Bald Hill coal and another hill east of Bald Hill rises to a considerably greater height, though not to the horizon of the Flint Ridge shale, as does Bald Hill, 100 feet above the coal. The reservoir lies in a depressed region in Union and Licking townships, but is bounded on the east by low hills. A trip through this region revealed the presence of Waverly shales and freestone, with characteristic fossils. A mile eastward, 45

feet above the T. & O. C. R. R. track at the reservoir, by combining various exposures a thickness for the Waverly of over 100 feet at least can be made out. Thornville is about 180 feet higher than the railroad, and the Waverly shales west of Amsterdam are ten or twenty feet higher. A range of hills half a mile to the south of the National Road, rise to 280 feet and expose at least 85 feet of coal-measure sandstone and conglomerate, here of a white color and full of Lepidodendron stems and other plants. The base of the sandstone is marked by a line of springs. It is not now possible to compare these elevations with those farther north, but evidently the relations are precisely the same. Although a sub-carboniferous limestone is marked on the map published by the Ohio Geological Survey, no indications of its existence were seen in Licking county. On the other hand, the Waverly seems to extend to the base of the coal-measures exactly as elsewhere.

Passing east from Newark many exposures of the Waverly are found along Licking river, but the most characteristic exposure is in a large quarry (the largest in the country), in the southeastern corner of Newark township. It is possible to trace the whole section from Licking river to the top of Bald Hill, in the southwest corner of Madison. The results of our study are embodied in the section accompanying.

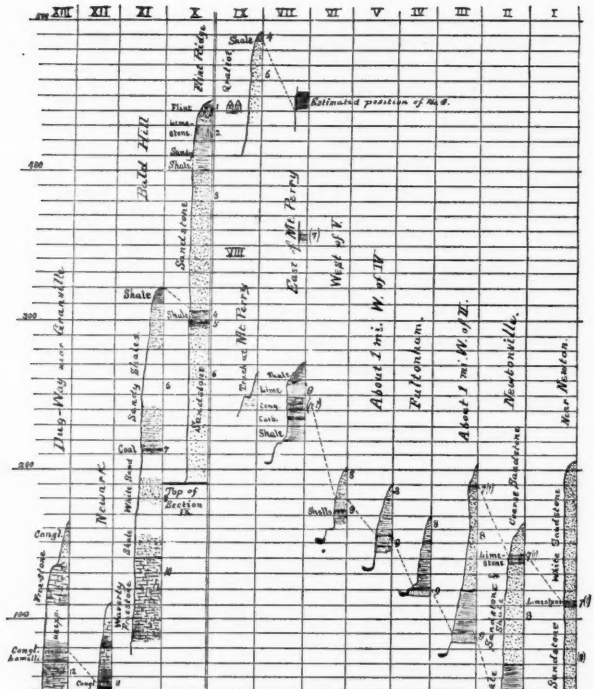

Fig. 2. GROUPED SECTIONS FROM GRANVILLE TO NEWTON.

Franklin and Hopewell townships are very rough and are intersected in every direction by valleys. Flint Ridge, the highest portion of the county, furnishes the best continuous section of the coal-measures. In the southeastern part of Madison township are several hills which reach within 200 feet of the top of Flint Ridge, *i. e.*, to beyond the base of the coal-measures sandstone. In the northeastern part of Franklin township are several hills exposing various parts of the coal-measure series which seems to dip rather strongly to the south. The coal at Flint Ridge occupies a small local basin and cannot be ex-

pected to prove continuous. It seems to lie some 160 feet above the Waverly. The highest hill in the county, so far seen, lies in Hopewell, a mile or more south of this mine, and its summit is 135 feet above the coal. The upper 30 fect or more is composed of the flinty limestone which caps the ridge. This limestone contains many impressions of foramifera (Fusulina cylindrica), and but few fossils, among which are Chonetes mesoloba, Productus longispinus, Pernopecten n. sp., Euomphalus sp., Productus muricatus, P. nebrascensis, and bryozoans. This hill is 250 feet above the National Road, directly south. This road is mended with the carboniferous shale of the horizon of the Flint Ridge coal. Near Brownsville the sub-carboniferous limestone is said to appear, but we have not been able to find it, and it seems impossible that so low a horizon could be reached.

It remains to take a hasty view of the region about Clay Lick Station, in Hanover township. Here in the middle of Hanover is a great development of the conglomeratic phase of the Waverly. One half mile east of Clay Lick there is a nearly continuous exposure of about 100 feet of alternating conglomerate and coarse sandstone of prevailingly red color. West of Clay Lick there is a considerable dip to the west or southwest. The dip is about seven feet to the hundred. At a distance of a mile south or northwest the exposure gives a dip of about 3.6 feet in the hundred to the northwest. These may be simply local flextures. It is altogether probable that a spit or bar extended into the sea northeast of Clay Lick and there great quantities of sand and gravel were accumulated, while the clayey deposits to the south and west were longer under the sea and sank somewhat under the weight of the massive deposits south of them. In the creek bed at the last mentioned exposure, a mile south of Clay Lick, is nearly a hundred feet of continuously exposed Waverly, showing none of the conglomeratic character found east of Clay Lick.

In order to define as nearly as possible the relations between the formations in Licking and adjoining counties, a hasty excursion was made into Muskingum county, with the results compendiously exhibited in the sections of Fig. 2. The barometic readings were interfered with by atmospheric changes in passing from Mt. Perry to Brownsville, so that the connection is not complete, but it is believed that the relations are relatively correct. Near Newton is a good exposure of over 200 feet, which is shown at No. I. The Maxville limestone is near the water and continues near the surface of the stream nearly to Mt.

Perry. The dip from Mt. Perry to Newton appears to be not less than 250 feet, with no noticeable change in the relative thickness of the exposed strata. The whole distance southeast represented by the grouped sections, is about 30 miles. The dip southeast accomplished in this distance is roughly estimated at from 300 to 350 feet, or something over ten feet to the mile; but the dip is much more abrupt after passing about six to eight miles east of Granville. It would seem from observations so far obtained that there is every where a rather abrupt decline along a line a short but variable distance from the edge of the coal field, so that the sub-carboniferous with a portion of the coal-measures extends outward in the form of a flat rim to the more concave central basin. In some places this line is almost of the nature of a fault and causes some obscurity. This line crosses the Licking river a mile or so east of Clay Lick.

In the next paper we shall be able to make more detailed comparisons of the faunæ represented. Enough is now known to assure us that many species have continued from the beginning to the end of this period. In other cases the coal-measures contain forms which might be considered the somewhat modified descendants of Waverly species. Nevertheless there are many, perhaps a majority of forms which do not exhibit a traceable connection with the Waverly or lower horizons. How much of this disparity is to be explained by the changed conditions of life—how much by the fact that the connection was with a different sea basin, and how much these categories leave unexplained, bids fair to prove a perplexing question. Such problems as these demand careful scrutiny and, if possible, adequate treatment.

CRUSTACEA.

Trilobita.

Only one species of trilobite has been encountered and this is fully described in connection with the discussion of Carboniferous trilobites upon a later page of this issue.

The only other remains suggesting crustacean affinities is the curious valve or plate, figure 21, Plate I. In some respects this resembles the valve of an Ostracode crustacean, with a very thick shell.

MOLLUSCA.

CEPHALOPODA.

Genus Orthoceras.

Orthoceras cribrosum, Geinitz. (?)

(Plate V, Fig. 2.)

There is but one species of Orthoceras at all abundant at Flint Ridge, and this is invariably more or less crushed. A smaller species like O. rushensis, has been doubtfully identified. An average example of our species is from three to four inches in total length, with a rather gradual expansion. About a fourth or fifth part of the shell below is without visible septa and is more rapidly expanded than the remainder, which is apparently cylindrical, having moderately concave septa, separated by intervals of about four and one-half into the width of the shell. The siphuncle is apparently nearly central (?) The shell is very thin and the epidermis apparently unornamented or granular. The removal of the epidermis reveals a nodose line near one side, the nature of which has not as yet been determined (Cf. O. duseri of Lower Silurian.)

It is by no means certain that the identification is correct. Geinitz laid stress upon the pitted nature of the shell, though his figure shows the epidermis to have been exfoliated.

Natilus sp.

(Plate II, Fig. 17.)

Fragments of what appears to be a Nautilus allied to N. forbesianus, McChesney, are not rare, but none of them indicate the shell to have been septate. Awaiting additional material these are inferred to be identical with N. decoratus of Cox, identified with the above.

GASTEROPODA.

GENUS BELLEROPHON.

Bellerophon percarinatus, Conrad.

(Plate II, Fig. 14.)

Shell subglobose; laterally expanded at the front; umbilici closed; outer lip thin at the front, thickened by callus at the sides; inner lip

thickened by callus, which is sometimes in the form of a broad, prominent lobe, and that at the median line; the last volution is always marked by one strong, rugose or nodose median carina, which extends from the inner lip to the front margin; in most cases there is a more or less distinct revolving ridge at each side of the median carina, and of equal extent with it; the whole surface is also marked by strong transverse wrinkles and lines of growth, but sometimes the lateral ridges are wanting. Length and breadth equal.

This species is represented by several recognizable fragments from Flint Ridge and Bald Hill. The description is quoted for reference.

Bellerophon nodocarinatus, Hall (*fide White.*)

(Plate III, Fig. 3.)

A number of specimens of a rather large Bellerophon are in exactly the condition figured by White, in the 13th report of the Geological Survey of Indiana. The lip seems to be but slightly expanded; general form, sub-globose; dorsal surface of outer volution, with a subnodose median carina which is divided by a furrow, in which at the bottom is a slightly raised line; on either side the carina a broad, shallow sinus; proximally the volution marked by prominent distant revolving ridges and the carina disappears; the carina seems to terminate in a slight dorsal emargination of the lip.

None of our specimens preserve the aperture or umbilicus. White is inclined to believe his *B. inspeciosus* a variety of this species.

Bellerophon (sub-cordiformis, sp. n.)

(Plate II, Fig. 7 a, b, c.)

A fragment of a small Bellerophon may be noticed, which appears to indicate a species entirely distinct from any known to the writer. Neither the mouth nor the umbilicus is visible, but the last coil is evidently very rapidly enlarged. The outline, as viewed from behind, is cordate; the diameter in the plane of the coils nearly equal to the width; middle of outer coil carinate, lip apparently regularly expanded; surface marked by oblique, revolving, rounded ridges, springing from the median carina and passing toward the lip, between these ridges are impressed lines, containing prominences disposed at regular intervals. This peculiarity of the surface markings alone is thought characteristic. Width, over 0.4 in., height about the same. Should

a name be required for this species it may be called *B. subcordiformis.* (A somewhat similar surface ornamentation is found in the otherwise very different *B. pullchellus* of Toula.)

Bellerophon Montfortianus, N. and P.

(Plate II, Fig. 1; Plate V, Fig 8.)

The largest Bellerophon found at Flint Ridge agrees with this fine species. We are able to give more complete figures than hitherto obtained, many of our specimens, though crushed, being entire.

Shell proximally very small, expanding rapidly; aperture enormously expanded, sub-reniform; outer volution with a deeply impressed medial sulcus emarginating the lip distally; lip thin, with a prominent callous where covering the inner coil. The surface is ornamented by strong revolving lines, which are separated by about ten striæ and are crossed by fine concentric striæ, giving the whole a delicate textile nature. In one of the specimens figured the revolving lines do not reach the lip, but the zone with only concentric lines seems due to exfoliation. The surface is also marked by distant concentric plications which become more numerous proximally. Width of aperture, 1.24, height, .95.

Bellerophon decussatus, Fleming ??

(Plate II, Fig. 12.)

Our figure represents the dorsal surface of the outer volution, which is marked by a combination of revolving and concentric striæ of nearly equal size and number. There is also a slight median fold. It is not certain that the identification can be sustained.

Bellerophon carbonarius, Cox.

(Plate II, Fig. 20.)

This, or a closely related species is represented by only a few fragments. (Cf. also B. stramineus.)

"Shell globose, broadly rounded over the dorsum; umbilical impressions very small or closed. Aperture transversely sublunate, much wider than high, and strongly arched, but not expanding more rapidly than the uniform increase of the size of the volutions; inner lip nearly wanting or little developed; outer lip moderately thick near the umbil-

icus on either side, but thinner between; sinus shallow and rounded, its band obscure or scarcely visible on the costated part of the outer whorl, sometimes a little concave, or with traces, on each side, of a faintly marked ridge on the smooth part of the outer volution; surface, except on the terminal half or third of the body whorl, ornamented with about 18-25 simple, rather distinct, revolving raised lines." This species is widely distributed.

Bellerophon marcouianus, Geinitz

(Plate V, Fig. 7.)

Several fragments are sufficient to indicate this species, but add nothing to the meagre description given by Geinitz and Meek. The shell is marked only by fine, close, unequal or alternating, revolving lines and has an aperture like B. montfortianus, which it approaches in size.

Bellerophon (cf. *crassus,* Meek and Worthen.)

(Plate V, Fig. 6.)

This Bellerophon is derived from the flinty limestone at the summit of Flint Ridge, and hence its horizon is 100 feet higher than the shells just described. Though much smaller than B. crassus, it has much the form of that species, yet the shell appears not to have been thick. The umbilical expansions of the lip are broken, but may have partly covered the cavity. The markings are nearly obliterated, but there are indications of a mesial ridge on the dorsum. The greatest diameter is over one inch.

Polyphemopsis inornata, Meek and Worthen?

(Plate II, Fig. 15.)

Even the generic reference of this specimen must remain doubtful, as it is so largely imbedded in the rock. If a Polyphemopsis, it resembles *P. inornata* as nearly as any American species encountered. *P. melanoides* from Newtonville would appear to be too slender. Our specimen is larger than the type of P. inornata.

Macrocheilus sp?

(Plate II, Fig. 16.)

A single specimen, pretty well preserved, but unfortunately not displaying the characters of the columella, seems to indicate a species of Macrocheilus, about the size and form of *M. medialis*, Meek and Worthen. The aperture is narrower, however, and the form of its lower angle is different. It is also but little larger than *M. subcorpulentus* of Whitfield, but until figures of the latter appear it will be impossible to compare them.

Macrocheilus sp?

(Plate II, Fig. 2.)

A second species is recognized from a badly flattened specimen, which is perfect enough, however, to show that the species is very like *M. planus*, though in its present condition it seems much more robust. In size and number of volutions it agrees very fully.

Pleurotomaria sp?

Figures 11 and 13 of Plate II, indicate a species of this genus with rather high conical spire and revolving as well as obliquely decussating striæ. I am not able to suggest its specific affinities.

Pleurotomaria newportensis, White (?)

(Plate II, Fig. 18.)

Volutions about five, regularly rounded, very convex, and rapidly diminishing in size; spire short; lower whorl marked by a spiral band originating at a notch in the margin of the aperture, consisting of an elevated striated ridge; otherwise marked with numerous revolving lines of which some are larger than others and separated by one or two of the smaller lines. It is by no means certain that our form is really this species. In the first place, the shell is flattened obliquely by pressure, so as to greatly distort the aperture and otherwise alter the form. Evidently, however, it was a shell of similar form and general appearance with P. newportensis. The striæ differ in being more numerous, though the obliteration of the minuter sort would remove this difference. P. newportensis is further described: Aperture sub-cir-

cular in outline, its margin oblique; outer lip having a broad notch a little above the middle; inner lip thickened. Our specimens indicate a species at least a third smaller than White's types.

Euomphalus sp?

(Plate II, Figs. 4, 5, and Plate V, Fig 5.)

A small species is represented by impressions and fragments of the dorsal and umbilical side. About three whorls are preserved, measuring .42 in diameter. The dorsal or upper surface seems to be marked by a sharp carina along the outer margin and to have been ornamented with strong lines of growth. The umbilical surface is less perfectly preserved, but had a series of sharp prominences along the inner margin and semi-carinate ridges elsewhere. Since writing the above more perfect and larger specimens have been found. This species is also found in the flinty limestone at the top of Flint Ridge. The existence of prominences along the inside of the umbilical whorls is a constant character, and the revolving lines seem less so. The sharp external carina of the opposite or upper side is also a character identical with E. rugosus, but this species differs constantly in the presence of the prominences on the umbilical edge of the whorl.

Genus Loxonema.

(Plate III, Fig. 2.)

A fine species of this genus is known from a single crushed specimen which is represented (partly restored) in our figure. The shell is 2.20 or more in length, the diameter of the largest whorl being about .75. The spire is elevated and has an apical angle of 15°. The number of volutions can not be less than ten (the terminal ones are absent in the specimen.) The volutions are convex and are marked by strong, somewhat oblique plications, about seven in half an inch on the largest volution. The characters of the lip, aperture and columella can not be made out, though there is some evidence of a projection of the lip downward at the lower angle of the aperture. The shell accords in most points which can be made out with L. plicatum, Whitfield, but, as there are in the neighborhood of twenty described

coal-measure species, many being similar, it is hazardous to identify it certainly with any of them.

LAMELLIBRANCHIATA.

Entolium aviculatum, Swallow.

(Plate I, Figs. 1, 2; Plate III, Fig. 10.)

It is submitted that it is impossible to rescue the Entoliums of the carboniferous from the inextricable confusion into which they have fallen. Nevertheless the name E. aviculatum doubtless applies to a species of wide distribution in the coal-measure rocks, however it may be related to sub-carboniferous species.

The remarks of Prof. Meek, under his description of an Entolium from the Waverly, are instructive as showing the difficulty of discriminating species in this group. He also says "Prof. Winchell's type [of Pernopecten shumardianus] seems to agree exactly, in all constant *specific* characters, with *Entolium aviculatum*, Swallow, already mentioned, from the coal-measures. So we have here a remarkable case of shells presenting extremely little or *no* constant *specific* difference, and yet differing in a character of the hinge that seems to be of *generic* importance."

Although Prof. Hall figures Pernopecten shumardianus from Newark, O., we have found no such form, though another and smaller shell apparently belonging to Pernopecten, is rarely found in the Waverly. We thought for some time that by mistake some Flint Ridge or Bald Hill specimens (coal-measures) had been labeled Waverly, but none of our numerous specimens from the coal-measure shales show the crenulated hinge prominences ascribed to the species in question. Mr. Meek, however, supposed P. shumardianus to be without the crenulated hinge and others have decided that Entolium is synonymous with Pernopecten. If that be the case it is difficult to see how E. aviculatum can be distinguished from Pernopecten shumardianus. The hinge in all specimens seen from the coal-measures shows, instead of a prominence, an impressed line on the left valve, at the point designated in Penopecten by a crenulated ridge, this appears on the *outside* of the valve as a ridge, the shell being very thin. On the ventral valve in the same position is a ridge, designed, it would seem, to fit into the groove of the other valve. The left valve, however, has its

ears produced upward so that the hinge line is straight and distant from the groves, while on the right valve the ridge is at the upper margin. Thus Prof. Hall has compared the hinge line of a right valve of Pernopecten limiformis with the left valve of P. shumardianus on Plate I, of the Report of the State Geologist of New York. The projecting ears of the left valve evidently prevent the easy dis-articulation of the valves in this monomuscular form perhaps especially liable to such an accident.

Shell very thin, compressed, very ineqi-valve, height of left valve noticeably greater than width; general outline (without the ears) acutely oval, lower outline a nearly regular curve, extending posteriorly about one third the height of the shell, anteriorly two-thirds the height, posterior margin thence proceeding upward nearly a straight but oblique line to the angle of the ear, but rather abruptly angled near the union of the upper and middle thirds of the height, the anterior margin is strongly curved inward at the same point and thence continued in a line at about the same angle as the opposite side to the ears, which project slightly upward so that the angles formed by the hinge line and the lateral margins are about right angles; position of the hinge of the opposite valve indicated by an impressed groove appearing outwardly as a ridge; ears set off by distinctly marked furrows; valve marked by numerous faint concentric lines and very feeble distant radiating striations.

Right valve as high as wide, its lower margin evenly rounded, the curve continuing on both sides to nearly ⅓ the height, the front side more produced and abruptly curved, front ear longer but less high, so that the hinge line, which is nearly straight, seems oblique to the long axis of the valve.

Entolium attenuatum, sp. n.

(Plate I, Fig. 11.)

A very slender species represented by a single left valve is derived from the flinty limestone at the top of Flint Ridge, and thus 100 feet higher than the horizon of the above named. This species was much more elongated, and had a very narrow hinge. The lower margin is uniformly but strongly curved, while the sides are nearly straight and inclined at a very acute angle to each other. The anterior margin

curves somewhat abruptly at its upper third, the posterior margin is straight. The ears are acute and depressed, while the beak is acute and somewhat elevated. There seem to be indications of the hinge ridge or furrow peculiar to this genus. Markings obscure, but apparently consisting of few radiating and many faint concentric lines. Length, 1¼ the greatest width. Hinge somewhat over ¼, the greatest width.

Genus Aviculopecten.

The literature at command makes an attempt to study the numerous members of this genus rather unprofitable, but in as much as several have been figured we may briefly allude to them.

Aviculopecten hertzeri, Meek.

(Plate I, Figs. 5 and 10.)

Specimens corresponding in size and form to Meek's type, are numerous, and occasionally one encounters the same shell of double the usual size, but retaining the characteristic marking. This species may be recognized by the close thread-like concentric and radiating lining producing a peculiar textile structure. This may be seen from the inside of the shell also. In the smaller specimens seen the shell sculpture is somewhat different. The entire shell is covered by strong radiating costæ in pairs, the costæ being closely crowded but separated by deeply impressed grooves between the pairs. These radiating lines are crossed by very fine and numerous concentric striations. The pairs tend also to again bifurcate toward the lower margin. This dichotomous arrangement of the very strong radiating ribs seems to distinguish this form constantly, though it may be, as at first supposed, the younger variety of A. hertzeri.

Aviculopecten? sp?

(Plate III, Fig. 18.)

The shell figured resembles *A.? sublobatus*, Phillips, but is still more elongate. It may be that the shell has suffered some distortion, though there little indication of it, and until other specimens are seen it will not do to rely too much on the figure. The left (?) valve fig-

ured is elongate, almost linguliform; beak acute, prominent; hinge line less than ⅓ the height of the valve, which is strongly convex near the median line and ornamented with fine radiating and concentric striæ.

Aviculopecten coxanus, M. and W.

(Plate I, Figs. 4 and 17.)

This little shell is not uncommon at Flint Ridge and Bald Hill, and curiously enough is generally preserved so as to expose the interiors, this fact led to some confusion, as the shell is so thin that the markings involves the whole shell and the inside is therefore a negative copy of the outer surface. Our largest specimen is of the size of the specimen figured by Meek, but presents the inner surface. This species may be recognized by the slight obliquity (more than indicated by Meek) and alternating striæ. The striæ seem to be uniformly more prominent than in the type, the striæ are also square in section. The posterior ear is acute with its posterior outline concave, less distinctly separated from the valve than the anterior ear, which is less acute. Length, .50; width, .49; hinge line, .40. About 14 primary striæ on the body of a valve of this size with alternating minute ones.

Aviculopecten scalaris, sp. n.?

(Plate I, Fig. 8.)

We have been tempted to regard this as a form of A. occidentalis, but there is a marked dissimilarity in the markings. The shell is equivalve, the valves nearly alike; somewhat longer than wide; hinge line shorter than greatest width; lower margin a uniform curve; front margin strongly curved, anterior ear separated from the body of the shell by a sharp depression; posterior ear larger, more excavated on its lateral margin and less distinctly marked off from the valve The valves are marked by fascicles of triangular, prominent striæ or ridges, which increase by bifurcation, usually with a feeble preference for dichotomy; these ridges crossed by sharply marked concentric angular depressions causing a resemblance to the treads of a stairway; also concentric lines most prominent upon the ears. The coarser wrinkles might have been thought accidental, but for the constancy with which they appear. After making the corrections indicated by Meek (Geo-

logical Surv. Neb., p. 192) in the figure of Geinitz, the dissimilarity in form is very slight and it is suspected a wider comparison would prove these shells identical.

Aviculopecten sorer, sp. n.?

(Plate I, Fig. 7, and Plate III, Fig. 16.)

We have a number of specimens of a fine species remarkable for the beauty of the surface markings, but all too imperfect to very satisfactorily characterize. The form, exclusive of the ears, is sub-triangular, both anterior and posterior margins being concave or nearly straight. The greatest breadth is below the middle and the lower margin is a uniform, rather shallow curve. The ears are large and sub-equal, the anterior are (?) most acute. Shell ornamented with prominent distant ribs separated by three or more smaller ones, all being nodose in the path of concentric markings or, rather, the nodose character produces the effect of concentric lines crossing the striæ. This shell resembles A. scalaris in general configuration very closely, more closely than indicated by the description, but it seems to vary greatly. The nodose character is also variable. No perfect specimen has been found, but many fragments indicate a species about the size and form of A. scalaris, with rounded distant striæ, separated by crowded finer ones. The ears are broken in all the specimens seen, but we presume the valve, Fig. 16, Plate III, is opposite to that of A. scalaris Fig. 8, Plate I, and so there is a slight difference in outline.

Aviculopecten sp?

(Plate I, Fig. 6.)

A little shell similar in outline to A. (Crenipecten) leon, Hall, is known from the single valve figured. It is peculiar in the relatively very short hinge and restricted ears, as well as in the ornamentation which consents of sharply defined, though small, ribs arranged in rather distant pairs. The specimen is a left valve and rather oblique. The general outline is acutely ovoid, the beak being nearly central and quite prominent. The posterior ear is very small and acute, anterior ear larger, with a more concave outline.

Crenipecten Foerstii, sp. n.

(Plate III, Fig. 9, 9a.)

The species figured is, next to Entolium aviculatum, the most common bivalve at Flint Ridge, and finds its counterpart in Streblopteria (?) tenuilineata, M. and W, Indeed, it is not improbable that the two are identical, in spite of marked points of divergence. It would be impossible to reconcile the description of that species with our specimens, while Meek's drawings are equally different. The reference to Streblopteria is certainly erroneous, although it is fair to add that Meek and Worthen had not seen the hinge. The genus Crenipecten, as defined by Hall, includes a diversity of forms ranging from such symetrical, long-hinged species as C. Winchelli to those oblique species represented by C. amplus and our own. A single specimen (Fig. 9 a.) from Mr. Foerste's collection, gave evidence of the crenulated hinge area, from the impression, the shell having been exfoliated. The characters of Streblopteria are as follows:

"Shell ovate or rounded, obliquely extended towards the anterior side; posterior wing broad, undefined, nearly rectangular, extending nearly as far as the posterior margin of the shell; anterior ear small, deeply defined; surface smooth or radiately ridged; one large, faintly marked, muscular impression a little behind the middle; one short, narrow tooth slightly diverging from the hinge on the posterior side of the beaks; ligament confined to a narrow, simple facet on the hinge margin."

In comparing our specimens with the figure of S. tenuilineatus we find, aside from its greater average size and different markings, that the anterior margin is more produced, and the anterior ear is much more sharply defined. There is little doubt that the two forms are at least congeneric.

Shell below the ears subcircular, but moderately convex, equivalve. Right valve with the anterior ear produced, rounded in front, separated from the valve by a deeply impressed, concave auricular sinus; posterior ear nearly rectangular, slightly concave in posterior outline, separated from the valve by an impressed line; hinge line one half the height of the valves. Left valve of same form, but the ears less distinctly separated; hinge line less than half the height, anterior ear with concave front outline. The beaks are acute and moderately

prominent. Surface marked by numerous close, minute, concentric lines, and numerous irregular, concentric wrinkles which give a peculiar appearance to the shell, not shared by other species. These wrinkles are less marked on young shells. There are also, in most cases, indications of radiating lines, which in the larger shells are strong striæ or ribs, at a distance from each other. Length of mature specimen .70, width, a trifle less, hinge of right valve, .34. A very similar, or probably identical form, occurs in the Waverly, which may prove to bear a name ranking the one now proposed.

Genus Lima.

Lima retifera, Shumard.

(Plate IV, Fig. 25; Plate V, Fig. 3.)

Shell obliquely subovate; posterior side short; anterior side obliquely produced; cardinal border rather short; lower margin a nearly uniform curve; anterior margin nearly equal, anterior one obtuse in outline, posterior ear rectangular; surface of valves marked by strong angular radiating costæ and concentric striæ. Height .50; length .70. Our specimens were, for the most part. very small, but otherwise agree with the description of this species, which is widely though not abundantly distributed.

Roemer, in his paper entitled "Ueber eine marine conchylien-Fauna im Steinkohlengebirge Oberschlesiens," figures a little shell, very much like this, but somewhat less oblique. He identifies it with a query, with Pecten interstitialis, Phillips.

Genus Solenomya, Lam?

The generic reference is here very doubtful. Two of the forms are evidently closely allied, while the other might probably be more properly referred elsewhere, if we knew anything of its hinge.

1. Solenomya (?) anodontoides, Meek.

(Plate IV, Fig. 10.)

This form agrees with Meek's description and figures, except that the anterior margin is much less acute, that portion of the shell not extending into a heel-like prolongation below, as represented in his

figure. The anterior margin is subtruncate in some specimens, and the lower margin is nearly straight and paraliel with the axis of the shell; the posterior margin is evenly curved, the greatest convexity being in the middle of the height of the shell. The largest specimen measures 1.20 in length and .75 in width, the smallest, 1.12 by .66.

The surface in each was covered by rather strong, variable, concentric lines. The middle of the valve is nearly uniformly convex, sometimes with a shallow depression extending from near the beak to the lower margin; shell slightly gaping behind.

2. Solenomya (?) meekiana, sp. n

(Plate IV, Fig. 9)

This is a much more elongated species or variety, otherwise almost identical, though the specimens observed were all smaller. Nearly quadrate, elongate, more than twice as long as wide; sides parallel, straight; posterior outline gently curved; anterior outline somewhat truncate, not produced; convexity somewhat greatest near the beak, but entire valve nearly equally convex, sloping gently and almost equally to the entire margin. Length, 1.05, width, .50. Surface marked as in the previous variety. Although Meek (Geol. Surv. Neb. p. 233; Plate IV, Fig. 7,) refers to Edmondia a species almost certainly identical with ours, as E. reflexa, comparison with the typical form, shows that it is far from probable that the specific reference (if the generic) could be sustained. It may be better to apply a new name, as suggested, and await farther evidence as to the relation to S. anodontoides.

Solenomya subradiata, sp n.

(Plate III, Fig. 8.)

This species somewhat resembles S. radiata, M. and W., but is much more elongated and expanded posteriorly. The shell is very thin and is somewhat compressed in the only specimens seen. Very narrowly oval and slightly convex; posterior dorsal line straight; posterior margin a regular curve; lower margin a uniform slight curve; umbo 4-5 the length from the posterior extremity, anterio-dorsal line convex, inclined abruptly from beak; anterior part of shell produced below in a strong "heel." Surface with very obscure concentric lines

and still more faint equidistant radiating lines. These latter are not very numerous and could easily be overlooked. Length 1.20, width .45.

The radiating striæ or impressed lines do not spring from the beak, but seem to terminate in the posterior hinge line; they are only obvious on the posterior third of the shell.

Genus macrodon, *Lycett.*

1. *Macrodon obsoletus,* Meek.

(Plate IV, Fig. 19.)

Shell elongate sub-quadrate or sub-rhombic, moderately convex, greatest convexity forming a gentle prominence extending from the umbo to the lower posterior margin. Upper posterior portion nearly plane, inclining gently to the obliquely truncated posterior margin; this part of shell only marked by faint radiating striæ. Hinge line straight, parallel to it two or three impressed lines separating the teeth, these showing in the partially denuded shell figured. Beaks removed but a short distance from the front margin. Anterior margin gently curved, meeting the hinge line by an abrupt right angle. Lower margin nearly straight or slightly convex. Entire surface marked by few concentric lines of growth.

2 *Macrodon tenuistriata,* M. and W.

"Shell small, rhombic-oblong, rather distinctly convex along the umbonal slopes and near the front, a little more than twice as long as high; basal and cardinal margins parallel, the former nearly straight or somewhat sinuous near the middle; cardinal margin straight, not quite equalling the greatest antero-posterior diameter; anterior side rounding up from below so as to meet the hinge nearly at right angles; posterior basal margin narrowly rounded; posterior margin obliquely truncated, often a little sinuous above; dorsal region behind the umbonal slope compressed; beaks compressed, a little flattened, incurved and rising somewhat above the hinge margin, located about half way between the middle and front; flanks broadly impressed or concave from the umbonal region obliquely backward to the faintly sinuous part of the base; surface ornamented by distinct marks of growth

crossed by radiating markings, well-defined behind, forming anteriorly crowded, obsolescent striæ."

Our specimens are smaller than those described by Meek, and more convex, but otherwise they agree. Length, .36, height, .16. This shell is almost identical in outline with M. obsoletus, but is much more gibbous. The possibility that it is merely the young of that species cannot be disputed.

3. Macrodon carbonaria, Cox.

(Plate IV, Figs. 21 and (?) 14.)

This is a very pretty and somewhat common species. It is easily recognized by the strong radiating ribs which are much more prominent in the area marked off by the posterior umbonal ridge. The largest specimen measures 1.40 long by .625 wide and is truncated obliquely behind. The concentric markings are plainly seen.

Figure 14 shows the inside of a valve which, from the inferior size and projecting anterior margin, could be identified with M. tenuistriata, M. and W., though, as the shell is but a fragment, it would be venturesome.

Genus Prothyris.

Prothyris (cf. *elegans,* Meek.)

(Plate IV, Fig. 3.)

The specimen on which this identification rests is imperfect and the anterior is not fully preserved. The description of the species is as follows: "Shell compressed, elongate oblong, the length being about three and a half times the height; ventral and dorsal margins straight or a little arched; the latter with a faintly defined marginal furrow, below which there is usually an obscure ridge, also parallel to the dorsal margin; posterior extremity obliquely sub-truncate, the most prominent part being below the middle; beaks compressed, depressed, not distinct from the dorsal margin, and placed about one-eighth or one-ninth the length of the valves behind the anterior extremity; notch of the anterior margin well-defined and extending about one half way up to the beaks; ridge from the inner angle of the notch narrow, flat, widening slightly from above; anterior margin above the

notch rounded, and having the appearance of a flattened ear; surface striæ nearly obsolete on the upper half of the valves, and more distinct on the ventral and antero-ventral regions."

Genus Allorisma.

Allorisma costata, M. and W.

(Plate III, Fig. 7, and Plate IV, Fig. 28.)

We have not been able to compare this fine species with types, but in spite of its great dissimilarity, notably in size, from specimens referred to this species by Mr. Meek, we regard this as identical with the Illinois species. The generic reference is far less satisfactory. Indeed, it is suspected that an examination of the hinge would prove this an independent genus.

Shell medium sized, elongate; upper and lower margins sub-parallel; beak prominent, anterior; anterior margin short, convex; shell produced and slightly attenuated posteriorly, posterior margin subtruncate; greatest depth of the shell a little posterior to the umbo; surface marked with (12) strong, distant concentric costæ extending from the anterior margin to the prominent posterior umbonal ridge, where they abruptly cease. The surface above the ridge being marked by fine concentric lines and a well marked ridge extending from the beak toward the centre of the posterior margin. Our specimens embrace impressions as well as the right valve. The space between the costæ is gently concave and smooth and there seems to have been a radiating rib upon the summit of the umbonal ridge into which the concentric ribs merge. There are indications of an impressed line along the hinge line posteriorly. The outline of the posterior margin seems in the best preserved specimen, bi-truncate, in others obliquely truncate in one straight line; other minor differences are referred to the conditions of preservation. Length, 1.40; height, .50. Comparisons were drawn in our note book with Orthonota, to which it may be allied.

Allorisma Geinitzii, Meek. (?)

(Plate IV, Fig. 27.)

This small species resembles, somewhat, A. gilberti, White, though it is by no means so much produced posteriorly. Shell very small,

elongate; not very gibbous; anterior dorsal margin inclined from the beak to the anterior end of the evenly curved lower margin, with which it united by an acute angle; posterior dorsal margin gently sinuous, four times as long as the anterior; posterior margin somewhat obliquely truncate, more prominent below; greatest height at the umbo, posterior part somewhat narrowed. Surface marked by irregular concentric striæ and, at least posteriorly, by a few indistinct radiating lines. Length, .33, height, .17. It is more probable that this species is new, but some hesitation is felt in separating it from a minute form of nearly the same outline, in view of the poverty of our material and the variability of the species.

Allorisma subcuneata, M. and H.

(Plate IV, Fig. 1.)

I am by no means certain regarding the identification of the fragments which have been referred to this species. However, it is certain that a shell of about the same size and having the same form about the umbo and the same coarse markings is found at Flint Ridge. The species, moreover, is widely distributed, occuring in Utah and New Mexico, as well as Indiana and others of the central states. The description is as follows: Shell large, twice or more times as long as high, gibbous anteriorly, compressed posteriorly, where the valves gape somewhat; basal margin nearly straight, curved rapidly near the anterior, more slowly at the posterior ends; dorsal margin convex posteriorly, giving the posterior outlines a somewhat spatulate form; front margin rather narrowly rounded; beaks projecting well beyond hinge line; surface marked by well defined concentric lines. Length, nearly four inches.

Genus Clinopistha.

Clinopistha radiata, Hall.

(Plate III, Fig. 11.)

Our specimen was associated with the forms elsewhere referred to Edmondia aspenwallensis, and resembles them very nearly. The outline differs perceptibly, however, and the faint and very rugular concentric striæ are quite unlike the folds which ornament the shell of

Edmondia. No traces of radiating lines are preserved, but the condition is such as to explain their disappearance.

Our specimen is rather less ventricose than that figured by White, but is also smaller. Length, .52, height, .46.

Genus Pleurophorus, King.

1. *Pleurophorus tropidophorus,* Meek.

(Plate IV, Fig. 15.)

This pretty shell is not uncommon at Flint Ridge. I am not sure that there are not two closely related species differing chiefly in size.

2. *Pleurophorus subcostatus,* M. and W. (?)

(Plate IV, Figs. 16 and 16a.)

We have a number of small specimens which vary so much among themselves that the variableness may account for some discrepancies between them and the description of Meek and Worthen. Ours is a smaller form and the larger examples have the sinuous lower outline of P. subcostatus. A very much smaller and more compact form figured on the same plate, Fig. 7. may be the young of the same species.

Genus Cypricardina, Hall.

Hinge unknown, shell elongate trapezoidal, moderately compressed, beaks anterior or sub-anterior, slightly prominent, surface marked by rather prominent concentric plications or striæ. (Hinge with well developed hinge-plate, with one linear tooth in one valve and two in the other, and other minute linear teeth shorter than the others, *Synopleura*, Meek.)

Cypricardina (?) *carbonaria,* Meek.

(Plate IV, Figs. 17 and 18.)

This shell was described from the locality whence our specimen came, so that it may be best simply to quote the description given by Meek: "Shell small, longitudinally oval, less than twice as long as high, the widest (highest) part being under the posterior extremity of

the hinge; rather gibbous, usually with a broad impression extending from the beaks obliquely backward and downward to the middle of the base of each valve; anterior side extremely short, or nearly obsolete, convex, and rounded; posterior side broader, more compressed or cuneate, with its upper edge straight and sloping obliquely backward to the regularly rounded posterior margin; base broadly and slightly sinuous in the middle, and rounding upward at the extremities; hinge line straight, between one-half and two-thirds as long as the valves, ranging at an angle of about 25 deg. with the oblique, longer axis of the shell, so as to meet the sloping upper edge of the posterior margin at a very obtuse but moderately well-defined angle, this imparting to the somewhat compressed posterior dorsal region a very faintly alate appearance; beaks extremely oblique, depressed nearly to the dorsal margin, very nearly terminal, and scarcely projecting beyond the rounded outline of the anterior extremity. Surface ornamented by fifteen to twenty exceedingly regular, well-defined, sub-imbricating, flattened ridges or undulations, that gradually become smaller and more closely approximating on the umbones. Length of largest specimen seen 0.55; height at the posterior extremity of hinges .32."

The specimen figured is but 0.45 long, but agrees well with the description, it being a partial cast, showing hinge teeth distinctly.

Gervillia (?) ohioense, sp. n.

(Plate IV, Fig. 13, and Plate III, Fig. 12.)

(Cf. *Avicula longa*, Meek.

Two specimens have been secured from Flint Ridge, both somewhat imperfect, but indicating a species quite different from Monopteria gibbosa. The whole question of the generic affinity of the carboniferous species referred to Gervillia, Monopteria, Blakevellia, etc., is very obscure.

The upper outline is nearly straight; beak distant nearly one-third the length from the anterior margin; posterior wing greatly produced, posterior margin deeply sinuous; posterior, produced part of shell keeled; anterior wing acute, its margin very oblique and slightly curved to its junction with the lower margin, with which it forms a continuous symmetrical curve. Hinge line, .65, height, .45, greatest length, .85.

The surface is marked by rather obvious concentric lines. The postero-inferior projection is greater than that of the hinge line. Fig. 13 of Plate IV, represents a specimen in which part of the posterior outline is obscure, while that figured on Plate III, Fig. 12, had its antero-inferior outline crushed in. By combining the figures a fair idea of the shell can be obtained. The specimen figured on Plate IV, is much flattened and somewhat distorted, it should be restored by producing the upper, posterior angle and the lower, posterior lobe. From *A. longa*, which it most resembles, it differs in being not only larger, but less produced posteriorly, the posterior sinus is much less and the anterior part of the shell does not appear to have the oblique sulcus described for that species. (We have, since writing the above, found the long posterior tooth characteristic of Avicula.)

Myalina (*cf. recurvirostris,* M. and W.)

(Plate V, Fig. 4.)

A single fragment indicates a species of nearly the size of the species quoted. It is not sufficient, however, to furnish the basis for accurate identification. The outline probably is not correctly restored in our drawing, but the shell was flattened, causing uncertainty as to the natural course of the striæ. The surface is marked by very coarse but regular and distant furrows, as well as the finer concentric lines.

Myalina sp?

(Plate IV, Fig. 20.)

Only a small fragment was found to indicate a species like M. Meliniformis, M. and W. It belongs to the group of M. subquadrata, M. sublamellosa, Eldridge, M. perattenuata, Meek, M. Flemingii, King, etc., but is a very small species, with acute beaks and strong striæ.

Myalina (?) *swallovi,* McChesney.

(Plate IV, Fig. 6.)

This familiar and widely distributed species is common here also. The general aspect is unlike most species of Myalina, but more like

Modiola. The surface is marked by few indistinct concentric lines.

GENUS AVICULOPINNA, Meek.

"Very elongated subtrigonal, equi-valve, with slightly indicated sub-terminal beaks, the shell being produced in front of them, gaping posteriorly; hinge line very long, edentulous."

1. Aviculopinna americana, Meek.

(Plate I, Fig. 20.)

Our fragmentary specimen is insufficient to warrant a description, but is obviously a member of the old genus Pinna. In size and ascertainable characters it seems to correspond with the species quoted above. We are unable to discover that the beaks are not anterior, but this may be due to the imperfect condition of the fossil. The character of the ligament grooves is well shown in this specimen. The only tangible distinction between Pinna and Aviculopinna being the position of the umbo, the generic reference is but provisional.

Solen? sp?

(Plate I, Fig. 19.)

We have figured a fragment which seems to indicate a Rasor shell about as completed in outline in the drawing. The piece is too small to characterize, but attention is called to it to stimulate collectors to examine the rocks for more complete specimens.

Edmondia (cf. aspinwallensis, Meek)

(Plate IV, Fig. 4,; Plate III, Fig. 17.)

We have a considerable number of specimens of various sizes, but all of the larger individuals are imperfect, while the smaller ones differ considerably from the species quoted. The shell is covered with strong concentric folds and very numerous striations. The posterior margin is broadly and evenly rounded (sub-truncate in the larger ones); the beaks are not prominent; the lower outline is a regular curve; the anterior margin seems much shorter than in types of E. aspinwallensis; the convexity is greatest in front and above the middle and there is sometimes a posterior umbonal ridge, nearly reaching the mar-

gin. Hinge and beaks not clearly seen. Length of small specimen, .55, height, .50; larger specimen, .85 by .70.

GENUS ASTARTELLA.

Astartella Newberryi, Mek.

(Plate IV, Fig. 33.)

This species is very abundant and varies in size greatly, but adheres strictly to the same type.

Astartella vera, Hall. (??)

A species about the same size as the last is less abundant, it seems to correspond with the form figured in the second vol. of Ohio Paleontology, Plate XIX, Fig. 1. It differs in outline from the latter, but the shell figured was evidently broken, as shown by the direction of the concentric ribs, the posterior wing being broader than represented. It differs from A. Newberryi, chiefly in the somewhat coarser striæ.

Astartella varica, McChesney.

(Plate IV, Fig. 31.)

This species is not very well represented in our collections. It attains as great or greater size than A. Newberryi, but is more flattened, with only a slight posterior umbonal ridge, but the specimen figured in the Ohio Paleontology, was evidently badly flattened, as the umbonal ridge is much more distinct than there represented. Several of our specimens were in the same state of preservation.

GENUS MICRODON, Conrad.

The reader is referred to the discussion of this genus, in the 13th Annual of the Indiana State Geologist. It seems very probable that our specimens are generically if not specifically identical with the little shells found in the Spergen Hill, Indiana, limestones.

Microdon (cf. subelliptica, Hall.)

(Plate IV, Fig. 32.)

Both valves are preserved and are nearly alike. Shell very small, somewhat trapezoidal, obliquely truncate behind, height over four-fifths the length, gently and evenly convex; dorsal margin, behind the beaks nearly straight, the gently concave cardinal margin forming nearly a right angle with it; lower margin a uniform curve. Posterior umbonal region evenly convex, but with evident ridge. The surface of the shell is marked by fine yet distinct concentric lines, there being about 21 upon a shell .20 high. Although the hinge has not been seen it seems reasonably sure that the generic reference is correct, making the first instance we remember of its occurrence in the coal-measures.

GENUS NUCULANA.

Nuculana bellistriata, Stevens.

(Plate IV, Fig. 26.)

This very pretty shell is abundant. Our specimens are much smaller than the types. They resemble in form and markings the European Leda attenuata, yet probably are correctly identified with the West Virginia species. The species occurs also in Indiana.

GENUS SCHIZODUS, King.

Shell trigonal, rounded anteriorly, attenuated behind; rather thin, smooth, with an obscure oblique ridge; ligament external; hinge teeth 2.3, rather small; anterior adductor slightly impressed, removed from the hinge, with a pedal scar close to it; pallial line simple.

The reference of species to this genus upon the evidence of external form alone, can only be provisional. There are over twenty species of fossil forms attributed to this genus.

Six species from the coal-measures of this country are described, while there seem to be at least four forms among the specimens derived from the shales at Flint Ridge. It is frequently difficult to determine what variations are due to distortion, especially in thin-shelled specimens like these, which are usually more or less flattened. The

American species are S. cuneatus, wheeleri, amplus, perelegans, occidentalis, and curtus.

1. Schizodus affinis, sp (?) n,

(Plate IV, Figs. 22 and 22a.)

This species is represented by nearly perfect casts of both valves, which are similar in form though various in size. The description will refer to the specimens rather than the species they represent. Right valve ovate, sub-trigonal, greatest convexity being about one-third from beak and one-third in length; anterior margin broadly curved, its curve varying littie from an arc of a circle, a little truncated above; lower margin much less curved to the sharp angle at its posterior extremity, which is produced as the termination of a prominence beginning at the umbo as a sharp ridge extending as a low fold to the margin; posterior margin slightly convex, inclined forward entering the upper margin by a gentle curve. The beak is distant one-third the greatest length from the anterior margin and is but moderately convex. Surface apparently with fine concentric lines and deeper lines of growth. Length, 1.20, width, 1.03; convexity apparently not over 0.50.

Schizodus cuneatus, Meek, differs most notably in the position of the beaks, which are located only one-quarter from the anterior margin, and as a result, the posterior part of the hinge line is much longer and the anterior broad margin as seen in our shell is absent. Our specimen as figured is possibly somewhat flattened.

2. Schizodus sub-circularis, sp. n.

(Plate IV, Fig. 24.)

A still smaller species or variety from the same rocks differs chiefly in having the beak near the middle line of the shell. It is known from a single left valve. The anterior and lower margins are continuous parts of almost a circle, which is only a little produced posteriorly; the posterior margin is inclined; beak sub-median, posterior umbonal ridge not sharp. The shell is moderately convex and is nearly smooth, except for the distant lines of growth. Length, .63, width, .59, convexity, about .20 (single valve).

3. Schizodus wheeleri, Swallow.

(Plate III, Fig. 15.)

This species is identified beyond question and is recognized by the great prolongation of its posterior side. The beaks are prominent and situated over one-quarter the length of the shell from the anterior margin. The anterior part of the shell is moderately convex, while that posterior to the sharply defined umbonal ridge is greatly compressed. The lower margin is very long and evenly convex, terminating posteriorly in a prominent acute angle; posterior margin obliquely truncate; dorsal margin deflected posteriorly. Length, 1.20; height, .80. Surface marked by very fine concentric lines.

4. Schizodus cuneatus, Meek. (?)

(Plate IV, Fig. 23.)

It is very strange that the original localities of this species have yielded us four species besides, but no typical example of that one. The fragment drawn is referred here only because it indicates a species produced posteriorly somewhat and different from S. wheeleri. I am inclined to believe that S. cuneatus is not a valid species.

5. Schizodus curtus, Meek and Werthon. (?)

A single specimen, showing parts of both valves, agrees most nearly with this species, but is more like a form figured by Meek, U. S. Geol. Surv. Neb., Plate X, Fig. 13d. This he says is probably a different species. In *S. curtus* the lower margin is straitened in front of the umbonal ridge, in this the regular curve is continued. *S. curtus* is so variable that it is not impossible that our species is identical.

6. Schizodus (?) spellmani, sp. n.

(Plate III, Fig. 14.)

A very perfect left valve collected by Mr. Spellman, forms the basis of this description. The shell is larger than either of the above, but falls short of the maximum of S. cuneatus, which it somewhat resembles. The margin valve is sub-elliptical, and moderately and evenly rounded; ventral margin forming a perfect semi-ellipse; posterior side long, posterior margin rounded, beaks moderately prominent,

rounded, at least one-third length of valves from anterior margin; hinge line straight behind the beak; posterior umbonal ridge rounded, not carinate; surface with imperfectly preserved fine lines of growth. This species obviously differs from the three above described. It would seem to resemble *S. amplus*, but in that the posterior margin is said to be vertically sub-truncated, also the posterior umbonal slope has a distinct sulcus not seen in this species.

GENUS PLACUNOPSIS, Morris and Lycett.

Placunopsis recticardinalis, Meek.

(Plate IV, Fig. 11.)

This species was described from Flint Ridge and hence the figure given by Meek is copied, although we have not found the shell as yet.

GENUS POSIDONOMYA, Brown.

Posidonomya fracta, Meek.

Only fragments of this shell which, as Meek says, is almost an exact miniature of the cretaceous Inoceramus problematicus were found.

BRACHIOPODA.

Lingula tighti, sp. n.

(Plate IV, Fig. 5.)

This name is proposed for a Lingula of medium size found in great numbers upon the lamellæ of earthy portions of fissile cannel coal at Flint Ridge, ten miles east of Newark, Ohio. This coal seam is number two in the section and has furnished considerable quantities of fairly good coal to local consumers. The Lingulæ occur in great numbers, covering the surface in places completely, and the coal is filled with them for a thickness of several inches. Valves nearly similar, elliptical, somewhat asymetrical; one margin nearly straight, the other more strongly curved, sides narrowed anteriorly and then rather abruptly rounded; width equal to over one-half the length; beak nearer the straight margin; shell covered with brown, finely striate epidermis, which is well preserved; striæ very numerous, crowded, but

regular, somewhat umbricated about the beaks. Length, .50–.60; width, .30.

This species resembles rather closely L. melie, Hall, but is not narrowed toward the beaks as much as in that species, neither has it the rather prominent mesial sinus. Our species is more oblique in front.

The European *L. mytiloides* is also very similar, but seems to be uniformly smaller and more nearly resembles *L. melie* than our specimens. Named for the discoverer Mr. Wm. G. Tight, of Granville. We have thought this a possible variety of L. umbonata, Cox, a shell common in the coal-measures. It is nearly of the same size, but is relatively longer and the margins do not approach each other above as rapidly. It is quite characteristic of our species that the breadth of the shell at one-fourth the length from the beaks is equal or even greater than the width at the same distance from the front margin. The occurrence of this Lingula in cannel coal along with broken fern fronds supports the theory that it was formed under water by debris brought in by streams or otherwise.

Athyris subtilata, Hall.

(Plate I, Fig. 18.)

This common and widely distributed species seems not to be abundant in the rock under consideration, only a few specimens having been secured.

Shell somewhat ovate, longer than broad, front margin nearly circular; valves very nearly equally inflated; ventral valve rather more convex, the greatest convexity being one-third the distance from the prominent arched beak; mesial sinus obscure, except toward the front of the valve, hypodermis marked with radiating lines which sometimes appear through the shell, especially that at the bottom of the sinus; epidermis marked by concentric lines of growth; dorsal valve uniformly convex, without evident fold and with short approximated beak. The radating lines on the dorsal valves are less regular—they are simply lines impressed upon the shell by the viscera.

Spirifera opima, Hall.

(Plate II, Fig. 23.)

Shell rather small, moderately convex, nearly semi-circular to

transversely oblong, variable. Ears and middle of ventral margin rarely salient. Hinge line nearly or quite equal to the greatest width of valves. Ventral valve evenly arched, most prominent one-fourth distance from beak to ventral margin; lateral portions rounded, not reflexed; beak moderately prominent, considerably incurved; area of medium size, marked with numerous obliquely upright ridges; foramen rather broad; mesial sinus rather sharply triangular in section, but not very deep, bearing a medial and four lateral plications, which are also impressed upon the cast, but do not extend to the beak, however; costæ of the lateral slopes of the valve triangular in section, moderately large, varying in number between 10 and 14, usually not bifurcating, but occasionally increased by implantation, costæ toward the lateral margins, merging into the area before reaching the beak. Dorsal valve rather less convex, greatest prominence being nearer the middle than in the ventral valve; beak projecting slightly, incurved; mesial fold about in correspondence with the sinus, bearing five or six simple or bifurcating costæ. The form of the cast of the ventral valve is sufficiently illustrated by our figure, also the fact that in this species the hinge area of the ventral valve is ribbed—a point hitherto unnoticed.

Spirifera camerata, Morton.

(Plate II, Figs. 22.)

This is the commonest Spirifer and one of the most characteristic fossils of the coal-measures. It is found rarely at Flint Ridge and Bald Hill in specimens of rather more than medium size.

Shell somewhat trihedral, the hinge line being longer than any other part, often pointed or mucronate. Ventral valve arched, with a prominent incurved beak; area concave, not very acute toward the extremities, with an almost equilateral foramen, which is partly closed by a pseudo-deltidium; the mesial sinus is deep, triangular in section, continuous from the beak to anterior margin. Dorsal valve less convex; mesial fold well defined, high; sides of the valves nearly uniformly inclined to the lateral margins, beak small, slightly produced. Both valves covered with moderately strong radiating ridges which soon increase by division, the cetral one remaining strongest so that they are grouped in fascicles of from three to five; striæ covering both sinus and fold; shell also marked by concentric ridges.

Spirifera, sp?

(Plate II, Fig. 6,)

A very transverse species is indicated by the cast figured, which can not be identified with any known coal-measure species. The nature of the specimen forbids making it the subject of a formal description. It is clearly related to Waverly forms.

SUB-GENUS MARTINIA, McCoy.

Dorsal margin shorter than the width of the shell, the angles of the hinge-margin shortly rounded; surface smooth or with punctate (spiniferous?) concentric lines, often with less distinct sub-epidermal radiating striæ; spiral lamellæ small.

Species of this group appear in the Silurian and continue into the carboniferous.

1. Spirifera (Martinia) planoconvexa, Sch.

(Plate I, Fig. 12.)

This little shell was found but once in the shales above the Flint Ridge coal. It is one of the commonest and most widely distributed coal-measure species, very possibly identical with *S. Urii,* Fleming, of Great Britain.

Length and breadth nearly equal; the lateral and lower (front) margins forming a continuous arc like a segment of a circle; ventral valve rather tumid, being most convex near the middle; beak produced beyond the hinge line, incurved; foramen narrow; area concave; dorsal valve flat with minute somewhat incurved beak; surface of both valves granular, with few, rather indistinct concentric lines.

2. Spirifera (Martinia) lineata, Martin?

(Plate I, Figs. 13a, 13b, 13c.)

The second species is considerably larger than the first, indeed, it is not certain that two species are not here confused. That figured on Plate III, Fig. 23, was imperfect, but so far as preserved seemed to agree with S. lineata, as identified by American writers. In this specimen, which was largely denuded of the shell, the radiating striæ were very evident and yet on such portions as still retained the shell

the concentric markings were much more prominent. A peculiar feature is the existence of two rib-like costæ, extending from the beak to the front margin of the valve, which costæ pertain to the sub-epidermal part of the shell rather than the surface. Our second specimen, as figured on Plate 1, is nearly circular in outline and with very little evidence of radiating striæ, while the concentric markings are very prominent. This form may be distinguished from S. planoconvexa by the great convexity of the dorsal valves, as well as its greater size and the prominence of the beak of the ventral valve. Length, 14 mm, breadth, 13 mm., convexity, 8 mm.

Productus Cora, Owen.

(Plate II, Fig. 26)

Productus cora, Owen, Geol. Rep. Iowa, etc. Pl. V, Fig. 1. 1852.
Productus semireticulatus, Hall. Stansbury's Rep. Salt L. 411. 1852.
Productus Prattenianus, Norwood. Journ. Acad. Phila. iii, 17. 1854.
Productus æquicostatus, Shumard. Geol. Rep. Missouri, 201. 1855.
Productus cora, Marcou. Geol. N. A. Pl. VI. Fig. 4. 1858.
? Productus lævicostus, White. Journ. Bost. Soc. N. H., VII. 1860.
Productus Flemmgii, Geinitz. Carb.-format. u. Dyas in Nebraska, 52. 1866.
Productus Calhounianus, Geinitz (not Swallow) do. 1866.
Productus Konnickeanus, Geinitz, (not de Verneuil) 1860.
Productus Prattenianus, Meek. U. S. Geol. Surv. Net. 1872.
Productus Prattenianus White. Rep. U. S. Surv. 100 Mer. 1877. Also referred to in Ohio Geology as *P. æquicostatus*.

This is the most abundant species of productus in the Carboniferous of Licking county, making up almost the mass of the rock in many places, so that slabs may be secured whose entire surface is studded with the remains of this fossil. Yet, from the fragile character of the shell, it is rarely found not destroyed or broken. I transcribe Shumard's original description as a basis for the study of our forms.

"Shell large, broad, hinge-line equal to the greatest width of the shell. Dorsal valve much elevated, arched, visceral portion slightly flattened on the middle, sides falling rather abruptly to the ears. Ears large, triangular, with three or four broad folds, which are not con-

tinued across the visceral portion. Just within the cardinal border is a range of four or five small tubes on either side the beak. The beak is moderately obtuse, and passes a little beyond the cardinal border. The surface is covered with longitudinal rounded ribs, which, at from about one-fourth of the distance from the back, preserve nearly an uniform width to the front margin. Some of the ribs bifurcate near the beak, and then continue without further division, the spaces between them being occasionally supplied with new ones; they are nearly straight on the back of the shell, on the sides they are curved toward the lateral borders, and rendered flexuous by the folds. At ten lines from the beak there are fifteen ribs in the space of five lines, the whole number is from 150 to 160 The surface is studded with slender tubes, which in some specimens are separated from each other by pretty regular intervals, and arranged in oblique line across the shell;. in others they are scattered promiscuously over the surface.

Ventral valve concave, visceral portion nearly plane, subquadrilateral, with several folds which continue across the shell; these are prominent on the ears and side, but become obscure as they approach the middle.

Productus punctatus, Martin.

(Plate II, Fig. 29.)

This is also a widely distributed species which is not very common at Flint Ridge. Attaining a large size; shell thin, varying from subquadrate to longitudinally subovate, sometimes wider than long; hinge line always shorter than greatest width of valves; anterior outline regularly rounded or slightly sinnous in the middle. Ventral valve gibbous with a merial flattening or depression extending from the front nearly to the beak. Ears compressed, small (the specimen figured is distorted by pressure). Dorsal valve somewhat concave, with a slight medial prominence. Surface marked by regular, rather conspicuous, distant, concentric ridges, supporting numerous appressed spines. Length, 2.50, breadth, somewhat less.

Productus longispinus, Sowerby.

(Plate II, Figs. 25, 27, 28.)

This very common and characteristic shell is one of the most

abundant fossils in the shales and limestones of the coal measures. Fig 25 illustrates the structure of the interior of the valve.

Productus muricatus, N. and P.

This form, often called a variety of the above, differs so constantly from P. longispinus as to be worthy of a distinct name. It is less common than the above and may be recognized by the fact that the striae are much coarser than in P. longispinus, and especially by the concentric wrinkles upon the dorsal part of the ventral valve, which inclines to become flattened in one plane.

Productus Nebrascensis, Owen.

(Plate II, Fig. 30.)

This widely distributed species is recognized by the peculiar nodulose character of the surface, the coarse radiating striae being crossed by irregular concentric ridges.

Productus costatus is very similar, as is *P. semireticulatus.*

Both last named species probably occur in these beds, but as the specimens do not now lie at command they are not enumerated.

Chonetes mesoloba.

Although not figured, this is one of the most abundant and characteristic fossils of the region and may be known by the prominent mesial fold. Its known vertical range in the county is over one hundred feet. A figure can be found in Dana's Manual p. 332.

Stricklandinia (?) *subquadrata*, sp. n.

(Plate I, Figs. 14, 14a.)

The generic reference is simply provisional, but the figures will illustrate the specific characters. One specimen is in the form of a cast showing some of the internal markings; these in some respects resemble Pentamerus. The general outline is almost exactly that of Lingula subquadrata of the Silurian, being subquadrate with parallel sides. The beaks are moderately prominent and the valves quite strongly convex. The shell is marked by rather strong distant striæ

parallel to the edge. The interior of the ventral (?) valve (Fig. 14) is marked by two bifid grooves anteriorly and many pits. The largest specimen seen measures .70 by .50 inches.

Hemipronites crassus, M. and H.

(Plate II, Fig. 19.)

This common Orthis-like shell is common to the sub-carboniferous and coal measures but is much less common in the latter in Licking Co. Specimens of this species occur sparingly at Bald Hill and Flint Ridge.

PROTOZOA

Fusulina cylindrica, Fischer.

(Plate III, Fig. 20.)

The Foraminifera are represented by one species which is obtained from the flint-bearing limestone of Flint Ridge. In many places the rock was almost entirely composed of these minute shells not larger than and nearly the shape of a grain of wheat. The shell is not preserved but the cavity bears the markings of the exterior which are unmistakable. This seems to prove that the flint bearing limestone was formed at some depth and its flint must very likely be accounted for by supposing it to be derived from silicious protozoa and spongue spicules. Although this species probably had a calcareous shell it suggests that conditions prevailed suited to the growth of siliceous forms

CORALS ETC.

A species of Zaphrentis (Plate II, Fig. 21.) is indicated by several poorly preserved specimens but these, as well as half a dozen species of Bryozoa, are reserved for a latter occasion. (See Appendix II.)

In conclusion we may remind the reader that this list is of necessity quite incomplete and hasty and that it has been prepared at a distance from means of accurate comparison with types and was designed to illustrate the richness of a single limited horizon and to

prepare the way for the intelligent study of the difficult group of rocks below.

In fact, a larger number of species than are here described have been already figured from the Waverly and only a beginning is yet made. These plates it was hoped to print at this time but circumstances forbid. In the neighborhood of eighty-five species have been collected by the class from the coal measures during a few hasty trips to Flint Ridge. This is as many as have been described from the coal measures of Indiana. Meek, in the Ohio Paleontology describes only about twenty.

APPENDIX I. CARBONIFEROUS TRILOBITES.

It was intended to devote space to a somewhat extended discussion of the carboniferous Trilobites of America but lack of space and the incompleteness of the discussion possible at present has induced us to give up the idea, especially in view of the hint that a special work is soon to appear upon this subject. The following notes are, however, appended to the present paper in the hope that they may prove useful.

It is well known that during the carboniferous period trilobites rapidly approach extinction and but few remained to struggle with the adverse conditions of the Permian. But why the seas of the carboniferous were less favorable than those of the Cambrian and Silurian remains a mystery. Although the trilobite of the early Palæozoic was, perhaps, a synthetic type as argued by Agassiz, it would seem that the trilobites of the carboniferous belonged to a closed type with slight powers of adaption.

A careful study of the trilobites of the carboniferous rocks of America ought to throw some light on these matters if undertaken in a truly comparative spirit rather than from the standpoint of the mere systematist. Nevertheless it is necessary to first devote the requisite systematic study in order to give critical value to determinations. A review of the whole field is necessary, but its difficulty has been much lightened by the works of two European authors from which many of our statements are drawn. (*Valerian v. Moeller.* Ueber die Trilobiten der steinkohlen formation des Ural, nebst einer Uebersicht und einegen Ergaenzungen der bisherigen Beobachtungen ueber Kohlen Trilobiten, 1867; *H. Woodward.* A Monograph of the

British Carboniferous Trilobites 1883-81 Palaeontographical Society, London.)

The first description of trilobite remains from carboniferous rocks was that of the Abbe' de Vitry in 1779. (3 Mem. de l'Acad. imper. et royale des sciences et belles lettres de Bruxelles, 1780.) Thirty years later William Martin described in his Petrificata Derbiensia a toilobite as *Entomolithus onicites Derbyensis*, which he regarded as a petrified insect related to Oniscus.

In 1836, Phillips' Geology of Yorkshire appeared, in which eight species were described, albeit very imperfectly.

Portlock, in 1843, published his Geological Report on Londonderry in which for the first time the attempt was made to set up distinct genera for the carboniferous trilobites. *Phillipsia* and *Griffithides*, the two prominent genera, date from this report.

De Koninck added much to the general fund of information, although his studies were restricted to Belgium.

M'Coy's Synopsis of the characters of the carboniferous Limestone Fossils added several species although none too well distinguished.

Family Proetidæ.

The four genera, Phillipsia, Griffithides, Brachymetopus, and Proetus, which constitute the family are all found in carboniferous rocks, while the first three are restricted to it, and Proetus begins in the Silurian. Phillipsia and Griffiides really constitute one genus with two types more or less closely united. In both, the general form is oval, the angles of the cheeks may be greatly produced, facial suture cutting obliquity across the posterior margin of the head-shield; thoracic segments nine in number; pigidium with 12 - 18 segments, margin rounded, not fimbriated.

Genus 1. Phillipsia, Portlock, 1843.

Glabella with nearly parallel sides; basal lobes, formed by a well defined furrow separating the posterior corners, distinct; middle of glabella marked by two or more lateral furrows; eyes large, facetted; cervical furrow deep.

Genus 2. Griffithides, Portlock, 1843.

Glabella, pyriforme, tumid, destitute of lateral furrows, eyes small smooth, cervical lobe broad.

GENUS 3. PROETUS, Steininger, 1830.

General form oval, head short, pigidium longer; head-shield with a raised border and furrow; angle of free cheeks sometimes produced; basal lobes of glabella distinct, with or without lateral furrows; axial furrows distinct, facial suture diverging in front of eyes to form prominent palpebral lobes. Free thoracic segments 8-10. Pigidium with elevated axis, pluræ falling short of margin of the pigidium, which usually is smooth.

GENUS 4. BRACHYMETOPUS, M'Coy, 1847.

Head shield nearly semicircular, acutish in front, one-third wider than long; glabella small, about one-half length of head, with basal, but no lateral lobes; facial suture obscure; angles of cheeks produced; surface pustulate; pigidum with a rounded border, ribs with double furrows, surface ornamented.

The following list embraces all the now recognized species of carboniferous trilobites, so far as can be ascertained. It must be admitted that many species have been described in this country from fragments too imperfect or too incomplete to afford adequate means of comparison.

GENUS DALMANITES (?)

1. *D. cuyahogæ*, Claypole, (Plate II, Fig. 33.)

GENUS PROETES.

1. *P. laevis*, Woodward.
2. *P. auriculatis*, Hall.
3. *P. ellipticus*, Meek and Worthen.

GENUS PHILLIPSIA.

EUROPEAN SPECIES.

Known from heads and pigidia.

A. Angle of free cheek produced to form a long spine.

I. Axial lobe of glabella not expanded in front.

1. *P. gemmulifera*, Phillips. Two lateral furrows on the glabella, axis of pigidium, with about 18 somites. (Plate VI, 6.)

2. *P. truncatula*, Phillips. Three lateral furrows on glabella, axis of pigidium, wirh about 18 somites. (Plate VI, 7.)

II. Axial lobe of glabella expanded anteriorly.

(a) of medium size.

†. pigidium rather longer than wide.

3. *P. eichwaldi*, Fischer. Head nearly semi-circular, eyes large.

3a. *P. eichwaldi*, var. *mucronata*, McCoy. Pigidium, with a median posterior prominence. (Plate VI, 8.)

4. *P. leei*, Woodward. Eyes very small.

‡. pigidium broader than long.

5. *S. cliffordi*, Woodward. Pigidium twice as wide as long.

(b). Of small size.

6. *P. minor*, Woodward.

B. Angle of free cheeks not produced to form a conspicuous spine.

I. Anterior margin of glabella not expanded.

7. *P. derbiensis*, Martin, (Plate VI, Fig. 12.)

II. Anterior margin of glabella expanded.

a. Pigidium wider than long.

8. *P. colei*, McCoy, (Plate VI, Fig. 11.)

b. Pigidium longer than wide.

9. *P. scabra*, Woodward.

Known only from pigidia.

10. *P. articulosa*, Woodward. Resembles P. cliffordi, differing in having seventeen coalesced somites instead of thirteen.

11. *P carinata*, Salter. Axis of the tail acutely ridged, seventeen segments.

12. *P. laticaudata*, Woodward. Pigidium very wide, with twelve somites, axis elevated.

American Species.

Known from both heads and pigidia.

1. *P. swallovi*, Shumard.
2. *P. shumardi*, Herrick.
3. *P. sagamonensis*, Meek and Worthen.
4. *P. scitula*, Meek and Worthen.
5. *P. doris*, Winchell.
6. *P. rockfordensis*, Winchell.
7. *P. insignis*, Winchell.
8. *P. trinucleata*, Herrick.

Known from pigidia or glabellæ only.

9. *P. meramecensis*, Shumard.
10. *P. missouriensis*, Shumard.
11. *P. major*, Shumard.
12. *P. cliftonensis*, Shumard.
(?)13. *P. stevensoni*, Meek.
14. *P. peranulata*, Shumard.
(?)15. *P. latispinosa*, Sandberger.
(?)16. *P. tennesseensis*, Winchell.

Genus Griffithides.

1. *G. acanthiceps*, Woodward, (Plate VI, Fig. 10.)
2. *G. brevispinus*, Woodward.
3. *G. calcaratus*, McCoy, (Plate VI, Fig. 16.*)

[*Figure omitted in plate, it lies above and between 11 and 12.]

(?)4. *G. carringtonensis*, Etheridge.
5. *G. glaber*, Woodward.
6. *G. globiceps*, Phillips.
7. *G. longispinus*, Portlock.
8. *G. moriceps*, Woodward.
9. *G. obsoletus*, Phillips.
10. *G. platyceps*, Portlock.
11. *G. seminiferus*, Phhillips.
12. *G. roemeri*, Moeller.
13. *G. gruenewaldti*, Moeller.
14. *G. bufo*, Meek and Worthen.
15. *G. portlocki*, Meek and Worthen.
16. *G. longiceps*, Portlock.

Genus Brachymetopus.

1. *B. discors*, McCoy.
2. *B. hibernicus*, Woodward.
3. *B. McCoyi*, Portlock, (Plate VI, Fig. 16.)
4. *B. ouralicus*, McCoy, (Plate VI, Fig. 14.)
(?)5. *B. lodiensis*, Meek, (Plate III, Fig. 4.)

Annotations on the above list.

Dalmanites ? cuyahogæ Claypole was described in the Geol. Mag.,

Decade iii, vol. i, p. 306, 1883. The specimen described was a nearly entire pigidium, differing from all known carboniferous species in the long spinous processes, which resemble those of Dalmanites.

It might be observed that the great size of the median lobe is suggestive that possibly the marginal part of the pigidium had been somehow removed, leaving the ribs irregularly preserved. The pigidium might then belong to *Brachymetopus*, but such a mutilation would most assuredly have been noticed by Prof. Claypole.

The specimens referred to *Proetus* consist of pigidia and fragments and the reference is based on analogy simply.

Of the species of *Phillipsia* figured, it is not necessary to give descriptions, while condensed descriptions of the others, as far as they can now be drawn up, are given.

The various authorities who have described *P. æqualis* (—P. posthumus,) disagree even in essential characteristics, so that for the present its position must remain doubtful.

P. articulosa is closely related to *P. cliffordi*, from which it differs in the greater number of coalesced somites.

"Pigidium [the only part known] one-fourth broader than long, axis one-third breadth, consisting of seventeen coalesced segments, which diminish rapidly in breadth to the extremity, which is bluntly round, and less than one third the breadth of the axis at the proximal end; axial furrows deeply marked. Pluræ 13, terminating abruptly within the margin, which is finely striated, unornamented."

P. carinata, is too imperfect in the specimens as yet discovered to be worthy of description.

P. cliffordi. Pigidium twice as long as broad, axis one-third the breadth at proximal border, rapidly diminishing to one-seventh; the border is posteriorly one-seventh the length of the pigidium, but diminishes laterally; axis of 13 somites, with 10 lateral pluræ, which bifurcate as they approach the margin, unornamented.

P. laticaudata. Pigidium much broader than long, very strongly trilobed; axis elevated, consisting of 12 somites; each strongly ridged and ornamented with a series of minute tubercles. Pluræ 9, broad for half their length, minutely ornamented, losing themselves near margin; length 6 mm., breadth 9 mm. Glabella tumid, imperfect.

Our restoration of the head of *P. lecl* is from badly distorted specimens and hence may not be accurate in every particular. The The pigidium is one-fifth broader than long, the axis forms one-third

of its breadth at the proximal border, but diminishes very rapidly, terminating in a somewhat blunt point near the posterior margin, About 14 somites, with about 9 pluræ, surrounded by a narrow, smooth border. The pigidium is more triangular that of *P. colei.*

P. minor is a very small species, having a pigidium resembling that of *P. eichwaldi.* Head shield rounded in front, one-third broader than long; glabella occupying one-third breadth, oval, slightly broader in front, tumid, with distinctly marked basal lobes; lateral furrow indistinct; neck-lobe rather prominent; angle of cheek produced into a short slightly curved spine.

P. quadrilimba is too imperfectly described to be recognized and might better be dropped from synonomy.

Griffithides brevispinus is known only from two fragments of the head. The author describes as follows:

"Head nearly twice as broad as long; free cheek, terminating laterally in a short spine; the eye, which is very smooth, is rounder and more tumid than in other species. The glabella is nearly smooth in front, and overhangs the anterior border of head-shield; posterior portion of the glabella and the neck-lobe irregularly tuberculated; free cheek also tuberculated, about 8 tubercles on each cheek, placed in a semicircle about the eyes. Margin of shield raised and striated."

G. ? carringtonensis is represented by pigidia resembling very much that of *G. obsoletus*, except that this species has 12 axial segments and has a distinct margin to the pigidium, while *G. obsoletus* has but 10 segments.

G. obsoletus. Pigidium one-fourth broader than long, composed of 10 segments, oxis much broader than plural portion; each of the 9 rib-like plicæ marked by a furrow down the centre, margin smooth. Glabella covered with peculiar striations.

G. platyceps was described from a fragmentary glabella, only and is not recognizable.

The two species of *Brachymetopus*, *B. discors* and *B. hibernicus* are founded on pigidia only and the outline drawings given will afford all the information we possess concerning them.

Meek's *Phillipsia lodiensis*, if a Brachymetopus, is the only member of this genus yet found in America.

We have thus hastily reviewed the exotic species and turn to a more careful study of the American forms. In the first place, let us examine the original descriptions.

GENUS PHILLIPSIA.

Phillipsia swallovi, Shumard.

Proetus swallovi, Shumard. Geol. Surv. Missouri.

"Head semi-circular, swollen, exterior border narrow, slightly elevated and marked with 4 or 5 thread-like striæ; sinus of the border shallow and indistinct; posterior border of cheeks rather wide, and limted internally by a shallow, but distinct groove; genal angle short and round?; glabella tumid, elevated above the plane of the cheeks; occupying about four-fifths the entire length of head, rather more than half as wide as long; front rounded; sides convex in advance of the eyes; slightly concave in the middle, and expanding again posteriorly; lobation indistinctly marked by three very shallow depressions on each side, the anterior and middle ones being nearly obsolete; occipital segment wider than the base of the glabella; occipital furrow slightly arched toward the front, narrow, rather deeply impressed, widest at the extremities; the furrow which separates the glabella from the cheeks [facial suture] is narrow, flexuous and slightly impressed; palpebraral lobes semi-oval, visual surfaces minutely reticulated. Thorax with 9 segments; axial lobe elevated, width greater than lateral lobes [pleural portions], rings rather wide, flattened in the direction of the axis; pigidium parabolic, moderately convex; length about equal to head; border rather wide; axial lobe elevated, as wide as lateral lobes; segments eleven, lateral lobes about seven, indistinct. Whole surface minutely punctuate; the punctures sometimes disposed in quincunx, and sometimes irregularly. Length of head, 3½ lines; greatest width, 6 lines."

The species is described from the Chemung, at Chouteau Springs, Cooper Co., Missouri, but it is suspected that the formation will be found to be really sub-carboniferous.

Phillipsia shumardi, Herrick.

Proetus missouriensis, Shum., Geol. Surv. Missouri.

Glabella tumid, greatest height about the centre, ovoid, obtusely rounded in front, truncated posteriorly, length a little greater than width, widest behind, three furrows on either side; posterior pair strongly marked, these commence at the dorsal sinus about one-third from base to front, pass in a curve backward, and bifurcate about midway between the sides and middle of the glabella, one branch very shallow,

is continued for a short distance almost transversely, the other bends back nearly to occipital sinus and, with the main branch, partially encloses a large oval lobe on either side, the lobes [basal lobes] separated by a space about one-half width of glabella; middle pair of furrows shallow, curving backwards in a direction nearly parallel with the posterior ones, but considerably shorter, anterior pair feebly impressed, a little oblique; occipital sinus a little convex toward the front, shallowest in the middle; occipital ring [neck-lobe] wide, flattened, much lower than the plane of glabella. Pigidium semi-circular, flattened convex, width double the length, margin broad and slightly concave; axial lobe almost as wide as the lateral lobes, rounded at the extremity, segments 10, separated by well-marked furrows; surface thickly studded with granulæ, which are rather smaller than those of the glabella. Length of head, 8½ lines; greatest width, 7½ lines; length of pigidium, 6½ lines; width 1 inch.

This species is also described from the Lithographic limestone said to be of Chemung age, but it occurs to in the Waverly (sub-carboniferous) of Ohio, at Granville. As this species is certainly a Phillipsia the name was preoccupied by *Phillipsia missouriensis*, Shumard, from Middle Coal Measnres at Lexington, Mo., described in 1858, Trans. Acad. Sci., St. Louis.

Phillipsia meramecensis, Shumard.

"Pigidium [only portion known] semi-elliptical, rather wider than long, very convex; border moderately narrow; axial lobe not quite as wide as the lateral lobes, and considerably elevated above them; anterior extremity arched; posterior extremity obtusely rounded; rings 13. convex on the dorsum, but shallow and narrow on the flattened sides; lateral lobes strongly arched downward; ribs about 12, indistinct, except the last two or three; the first four from the thoracic margin marked by a shallow, but distinct furrow, which is situated very near the posterior edge; furrows between the ribs rather deeply impressed. Surface very finely granulose. Length, six lines; width, 6½ lines."

Described from the so-called Archimedes limestone, in St. Louis Co., Mo. There is nothing characteristic about the pigidium described, though it may be readily distinguished from the previous one.

Phillipsia missouriensis, Shumard.

Pigidium semi-elliptical, elevated, width greater than length; sur-

face very finely punctate, punctæ rather distant and arranged somewhat in quincunx; margin rather broad and smooth; axial lobe strongly arched transversely, gradually tapering, forming not quite four-fifths the total length; its width equal to about three-fourths the width of lateral lobe; rings about 18, rounded on the dorsum and flattened at the extremities, transverse furrow narrow, distinctly impressed on the dorsum, becoming obsolete before reaching the longitudinal furrows; lateral lobes rather strongly arched transversely; anterior margin angulated, apex of angle elevated and situated nearest the axial lobe; segments eleven, rounded, curving slightly downwards, not furrowed; furrows between the segments rather deeply impressed, except the two posterior ones, which are quite shallow. Length, .68; width, .76; length of axial lobe, .56; width, .23.

Such a description of a pigidium simply can have but a local value.

Phillipsia major, Shumard.

Pigidium [only part known] large, elevated, approaching to semi-elliptical, a little wider than long; surface smooth, or very finely punctuate; outline of edges sinuate, margin broad, particularly toward the posterior extremity; axial lobe very much elevated, gently tapering, forming five-sixths of the total length, not so wide as the lateral lobe, rather strongly arched longitudinally, sides with a broad, shallow groove running their whole length; rings 23, very strongly arched from side to side to side, angulated in the lateral depressions and their extremities directed obliquely backward. The first 6 or 7 from the front are very flat in a longitudinal direction, and are separated from each other by fine, scarcely impressed, transverse lines or furrows. Posterior to these the furrows are distinctly impressed to the extremity of the lobe, while the rings become gradually more rounded on the dorsum, but on the sides they still continue flattened. Lateral lobes moderately convex, obtusely angulated in front; segments 12, rounded, slightly sinuate, simple; furrows rather strongly impressed, except the two last, which are nearly obsolete. Width, 1.20 in.; length, 1.10; length of axial lobe, .93; width at anterior extremity, .30.

This very large species has several peculiarities which may make it possible to recognize it from the description. It is said to have been derived from the upper coal measures in Kansas.

Meek was apparently in error in identifying the specimens figured

in his Paleontology of Nebraska, with Shumard's P. major. The former are characterized by a rather unusual length of pigidia, while those of the latter are broad. The pigidium Fig. 1, Plate II, of the Nebraska report closely resembles Griffithides obsoletus.

Phillipsia cliftonensis, Shumard.

Pigidium small, semi-elliptical, gibbous, width greater than the length; axial lobe elevated longitudinaliy, gently arched, dorsum slightly depressed, width at forward extremity about equal to one lateral lobe exclusive of smooth margin, gradually tapering and terminating in a blunt point posteriorly; rings from 13 to 14, sub-granulose, separated by distinctly impressed furrows; lateral lobes angulated near the middle, flattened above and on the sides, well defined from the margin by a shallow, but distinct furrow; segments 7, rounded, separated by distinct linear sulci; margin moderately wide and regularly convex. Length, .23; width, .25; heigt, .11; height of axial lobe, .04; length, .19.

This is also from the upper coal measures of Kansas.

Phillipsia sangamonsis. Meek and Worthen.

(Plate V, Fig. 13.)

Sub-ovate; cephalic shield convex, regularly rounded in front, cheeks produced into carinated processes less than one-third entire median length ef head; glabella convex, sub-inflated, axial suture moderately well defined, greatest convexity behind the middle, length 1¼ width, sides nearly parallel; posterior lobes large, prominent; second lateral furrow curved, oblique, anterior furrows nearly obsolete; cervical segment and suture well defined; facial suture quite well defined, intersecting posterior margin midway to angle. Eyes rather large, half as long as glabella, exclusive of cervical segment, prominent; palpebral lobes convex, resting upon the eye like a lid.

Pigidium semi-elliptical, rather convex, a little wider than long, narrow and rather longer than head, narrowing posteriorly, abruptly rounded behind; mesial lobe prominent, a little flattened at each side, narrower than the lateral lobes, from which it is separated by a broad furrow, about two-thirds entire length of glabella; lateral lobes less prominent, abruptly convex at outer side; segments 9 or 10, all terminating abruptly at the edge of a broad marginal zone, which is widest

posteriorly; surface smooth. Length of head, medianly, .50; breadth, .65; length of glabella, .35; width, .30.

This species is said to be rather common in the Western states, but it has not yet been secured from Ohio.

Phillipsia scitula, Meek and Worthen.

Elliptical; head semi-elliptical, tumid, one-third wider than long, anterior margin rounded, cheeks produced into spines extending to fifth thoracic segment; glabella broadly rounded, occupying the margin in front, most elevated posteriorly, axial sutures obsolete anteriorly, posterior lateral lobes rather large, very oblique, lateral lobes almost obsolete; cervical segment more prominent than the glabella, with a median tubercle, cervical suture deep; eyes one-half as long as the glabella; palpebral lobes semi-circular, convex; cheeks small; pigidium almost as long as head, narrower, mesial lobe prominent, wider than lateral lobes, border wide; surface granular. Entire length, .70; pigidium, .20; width of pigidium, 30; length of head, .25; width, .31.

Judging from the figures and descriptions this species is the nearest approach to Griffithides yet found in America. The presence of lateral furrows on the glabella indicate a member of Phillipsia, however, as the genera are now understoood.

Phillipsia doris, (Hall) Winchell.

Head surrounded by an outwardly inclined border marked off by a deep groove from the cheeks, which are produced into spines posteriorly one-third whole length of head shield; glabella prolately semi-elliptical, with large postero-lateral lobes, the lateral furrows indistinct; pigidium semi-elliptical, axial portion convex, diminishing to an obtuse point; lateral lobes somewhat narrower, bordered by a smooth marginal area, axis with 11 articulations, lateral lobe 7; surface obscurely granulose,

Winchell says, also "middle of the border (of head) marked by a groove which reaches a point opposite one eye, to the corresponding point on the other side of the head," which seems somewhat difficult to understand. The species was obtained from Rockford, Indiana. Width of pigidium, .55; length, .21.

Phillipsia rockfordensis, Winchell.

"Cephalic shield surrounded by a narrow, convex border, which

is bounded internally by a narrow, but deep groove, and terminates posteriorly in conically tapering genal points. The principal lobe of the glabella is relatively very large, convex, highest in the middle, widened anteriorly, circularly rounded in front, and gently curved on the sides; no glabellar furrows are present. The complimentary [postero lateral] lobes are large, oval, and project laterally farther than the main lobe. The surface of glabella finely, but sharply granulated; margin finely striated. Size about as that of *P. doris*. Collected at Rockford, Indiana."

P. insignis, Winchell, is closely allied to *P. meramecensis*, Shumard. Not having access to the original description I can only gather that the head is armed with spines "which reach twice the length of the glabella from the anterior end," and the eyes are large, while the pigidium has a plane margin.

P. howi, was described by Mr. Billings. It is said to be closely allied to the above, but has a greater number of annuli in the axis of the pigidium, which alone is known.

P. vindobonensis, Hartt, is described as follows:

"Pigidium semi-elliptical, very convex; (one or two segments appear to be wanting from the anterior margin of the only specimen seen,) but its width must have been greater than its length. Ten or eleven articulations are visible on the side lobes and twelve of the axis, which is very prominent and moderately tapering. The axial rings are depressed, convex, becoming smaller, more crowded, and more distant toward the apex. Ribs on the side lobes depressed, convex, decreasing in length, breadth and distinctness from before backward, while at the same time they become more and more inclined backward. The six anterior ribs preserved show a distinctly marked groove, originating on the posterior margin at about one-third the length of the rib from the axis, and running obliquely, increasing in depth to the end of the rib. Smooth border none, or extremely narrow at the anterior angles, but becoming three-fifths the width of the axis near the posterior part of the pigidium, which is not visible in the only specimen I have examined."

We have here, therefore, a species described from a fragment of a pigidium, exhibiting neither end and nothing else of importance, an example of puerility too often followed.

Phillipsia, trinucleata, n. sp.

A considerable number of specimens have been collected which were at first supposed to be *P. sangamonensis*, but are evidently quite distinct from any described species. It is not absolutely certain that the cheek spine belongs to the same species as the glabella and pigidia with which it was associated, yet the circumstances render it highly probable.

The glabella presents the most distinctive features. It is considerably longer than wide and quite convex, the greatest height being posterior to the middle. Anterior depressed margin rather narrow in front, expanded laterally; sides nearly straight or somewhat concave near the eyes; postero-lateral lobes very sharply defined, conical, oblique, with a second smaller pair in front of them, and a very faintly outlined second pair still farther forward; between the postero-lateral lobes a sharply defined, prominent, median elevation, almost as large as the others; cervical segment convex, high, often with a single median tubercle. The surface of the glabella is minutely ornamented and on either side in front of the eyes is an oval pit which has been thought by some to represent the insertion of the antenna or organ of sense.

The eyes are large and supported by a prominent palpebraral lobe. A single movable cheek has been found. The margin is obliquely inclined, forming a prominent angle at its union with the face; middle of cheek depressed and marked with an impressed line; cheek produced into a spine as long as the whole remainder of the cheek; length of cheek, .77 (the spine, .35); length of eye, .11. Pigidia are not rare and are very convex, the median lobe especially being convex from side to side and particularly prominent posteriorly. The median lobe occupies one-third or less the width of the pigidium proximally and tapers gradually, forming a portion of a regular truncate cone; on either side an impressed line marking off an accessory portion; axial segments 17-19; lateral lobes convex; pluræ flattened slightly above, separated by very deep sutures; margin broad, longitudinally striate, abruptly deflexed; ribs 9-12. Length of pigidium, .35; width, .45, length of axial lobe, .27. Another individual, length, .48, width, .56, axial lobe, width, .20, length, 40. The pigidium is generally, if not always ornamented by minute pistules on the summits of the segments which are borne on the top of a slightly elevated, flattened ridge forming the axis of the annuli.

PLATE I.

(Figures, unless otherwise indicated, natural size.)

Fig. 1. Entolium aviculatum, *Swallow*, left valve.
Fig. 2. Right valve of the same—p. 23.
Fig. 3. Aviculopecten ?
Fig. 4. Aviculopecten coxanus, *M. and W.*
Fig. 5. Aviculopecten hertzeri, *Meek*, or related species—p. 25.
Fig. 6. Aviculopecten sp?—p. 27.
Fig. 8. Aviculopecten scalaris, *Herrick*—p. 26.
Fig. 9.
Fig. 10. Aviculopecten hertzeri, *Meek*—p. 25.
Fig. 11. Entolium attenuatum, *Herrick*—p. 24.
Fig. 12. Martinia planoconvexa, *Sch*—p. 46.
Fig. 13. a, b, c. Martinia lineata, *Martin*—p. 46.
Fig. 14. Stricklandia? subquadrata, *Herrick*—p. 49.
Fig. 16. a, b, c. Athyris subtilita ??—cf. Pal. Neb. Plate I, Fig. 12.
Fig. 17. Aviculopecten coxanus, *M. and W.*—p. 26.
Fig. 18. Athyris subtilita, *Hall*—p. 44.
Fig. 19. Solen sp.—p. 38.
Fig. 20. Aviculopinna americana, *Meek*—p. 38.
Fig. 21. Ostracode crustacean? a single valve.
Fig. 22. Allorisma sp?
Fig. 23. Phillipsia trinucleata, *Herrick.*
Fig. 24. Productus sp. Small individual.

PLATE II.

Fig. 1. Bellerophon montfortianus, *N. and P.*—p. 19.
Fig. 2. Macrocheilus planus?—p. 21.
Fig. 3.
Fig. 4 and 5. Euomphalus sp.—p. 22.
Fig. 6. Spirifer sp.
Fig. 7. Bellerophon subcordiformis, *Herrick*—p. 18.
Fig. 8. Discina Meekana, *Whitfield*, with shell partly preserved.
Fig. 9. Under valve of same?
Fig. 10. Orbiculoidea? sp. Incorrectly drawn, the outline is not circular, but somewhat elliptical. Very likely the same species figured

but not named by Meek, in Paleontology of Nebraska, Plate IV, Fig. 3.

Figs, 11 and 13. Pleurotomaria sp.

Fig. 12. Bellerophon decussatus, *Fleming?*—p. 19.

Fig. 14. Bellerophon percarinatus, *Con.*—p. 17.

Fig. 15. Polyphemopsis inornata, *M. and W.*—p. 20.

Fig. 16. Macrocheilus medialis, *M. and W.*—p. 21.

Fig. 17. Nautilus sp.—p. 17.

Fig. 18. Pleurotomaria newportensis, *White*—p 21.

Fig. 19. Hemiphronites crassus, *M. and H.*—p. 50.

Fig. 20. Bellerophon carbonarius, *Cox*—p. 10.

Fig. 21. Zaphrentis, sp.

Fig. 22. Spirifer camerata, *Morton*—p. 45.

Fig. 23. Spirifer opima, *Hall*—p. 44.

Fig. 24. Spirifer striata?

Figs. 25, 27, 28. Productus longispinus, *Sowerby*—p. 48.

Fig. 26. Productus cora, *Owen*—p. 47.

Fig. 29. Productus punctatus, *Martin*—p. 48.

Fig. 30. Productus nebrascensis. *Owen*—p. 49.

Fig. 31. Productus sp.

Fig. 32. Phillipsia trinucleata, *Herrick*, decorticated glabella.

Fig. 33. Dalmanites? cuyahogæ, *Claypole*, pigidium.

Fig. 34. Unidentified gasteropod.

PLATE III.

Fig. 1. Macrocheilus sp?

Fig. 2. Loxonema sp.

Fig. 3. Bellerophon nodocarinatus, *Hall*—p. 18.

Fig. 4. Brachymetopsus lodiensis, *Meek.*

Fig. 5. Griffithides glaber, *Wotdw.*—restored.

Fig. 6. Phillipsia scabra, *Woodw.*

Fig. 7. Allorisma costata, *M. and W.*—p. 33.

Fig. 8. Solenomya subradiata, *Herrick*—p. 30.

Fig. 9. Crenipecten foerstii, *Herrick*, both valves of the same shell.

Fig. 9a. (near the centre of the plate) cast of same with impression of hinge line.

Fig. 10. Outline of Entolium aviculatum as found at Flint Ridge. Two valves in position, showing supposed relation.

Fig. 11. Clinopistha radiata, *Hall*—p. 34.

Fig. 12. Gervillia (Avicula) ohioense, *Herrick*—p. 36.

Fig. 13. Aviculopecten carboniferus. (Accidentally omitted from the list.)
Fig. 14. Schizodus (?) spellmani, *Herrick*—p. 42.
Fig. 15. Schizodus wheeleri, *Swallow*—p. 42.
Fig. 16. Aviculopecten sorer, *Herrick*—p. 27.
Fig. 17. Edmondia sp?—p. 38.
Fig. 18. Aviculopecten?—p. 25.
Fig. 19. Discina convexa, *Shum*, (?) Omitted from list.
Fig. 20. Aviculopecten sp?—above No. 19.
Fig. 21. Phillipsia trinucleata, *Herrick*.

PLATE IV.

Fig. 1, 2. Allorisma subcuneata, *M. and H.*—p. 35.
Figr 3. Prothyris elegans, *Meek*—p. 38.
Fig. 6. Myalina swallovi, *McChesney*—p. 37.
Fig. 7.
Fig. 8.
Fig. 9. Solenomya? meekana, *Herrick*—p. 30.
Fig. 10. Solenomya anodontoides, *Meek*—p. 29.
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PLATE V.

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Figs. 9 and 10. Outlines of large plates, apparently part of head armor of fishes, one-half natural size.
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Fig. 13. Phillipsia sangamonensis, *M. and W.* head.

PLATE VI.

Fig. 1. Griffithides globiceps, *Phillips.*
Fig. 2. Griffithides longispinus, *Portlock.*
Fig. 3. Griffithides longisceps, *Portlock.*
Fig. 4. Griffithides seminiferus, *Phillips.*
Fig. 5. Griffithides moriceps, *Woodward.*
Fig. 6. Phillipsia gemmulifera, *Phillips.*
Fig. 7. Phillipsia truncatula, *Phillips.*
Fig. 8. Phillipsia eichwaldi, var. mucronata, *McCoy.*
Fig. 10. Griffithides acanthiceps, *Woodward.*
Fig. 11. Phillipsia colei, *McCoy*, 11a, hypostome.
Fig. 12. Phillipsia derbiensis, *Martin.*
Fig. 13. Griffithides roemeri, *Moeller.*
Fig. 14. Brachymetopus ouralicus, *De Verneail.*
Fig. 15. Griffithides gruenewaldti, *Moeller.*
Fig. 16. Brachymetopus maccoyi, *Portlock.*
Fig. 17. Griffithides calcaratus, *McCoy.*
These figures are mostly reduced from Woodward's monograph, with slight modifications.

APPENDIX II. A WAVERLY TRILOBITE.

Since the preceding synopsis of Trilobites was put in type, a fine specimen of Phillipsia shumardi, (missouriensis, Shumard,) was found in the Waverly, south of Granville, by W. F. Cooper, which makes it possible for us to complete the description quoted on page 58, and to correct a few minor inaccuracies. This identification, which can hardly be open to the slightest question, will throw additional light on the position of the Lithographic limestone of Missouri.

Phillipsia shumardi, Herrick.

(Plate VII, Fig. 14.)

Proetus missouriensis, Shum., Geol. Surv. Missouri, p. 196. (See ante, p. 58.)

The description following is based upon an entire and nearly perfect specimen from the Waverly freestone at Granville, O.:

General form elongate, oblong elliptical, axial portions strongly elevated; outline of head somewhat parabolic, nearly twice as broad as axial length. Head shield very high axially, the height of the glabella being considerably more than one-fourth the entire width of the head shield; cheeks produced into spines reaching about to the third thoracic segment. The glabella is short and broadly rounded anteriorly, margin in front thickened to form a high mural ridge or lip separated from the prominent frontal portion by a deep sulcus; axial portion about one-third as wide as the entire head shield and scarcely expanded anteriorly, marked by three lateral sulci. The basal (posterolateral) lobes are large and oblique, separated by an interval equalling about half the width of glabella. The sulcus anterior to the lobes has a slight tendency to bifurcate and the two in front of it are faint and less oblique. The palpebral lobes are very large. The cervical groove is deep and abrupt and the cervical segment does not rise to the level of the median axial portion. The cheeks are extensive and decline greatly to a submarginal groove. The spine is of moderate

length and the margin is greatly rounded and exhibits (sub-epidermal?) striations. The eyes are unfortunately destroyed in all specimens seen, but evidently were large. The suture separating the fixed cheeks is also obliterated, but its position is approximately indicated in our figure.

The thorax consists of ten distinctly separated segments. The axial portion is high and evenly convex and the lateral portions are rather abruptly flexed near the middle of their width and the pluræ are high and convex, not sulcate. The pigidium is one third wider than long (Shumard's specimen was a fragment) and the postero-lateral outline is a perfect arc of a circle, whose centre lies axially about four-fifths its length from the posterior extremity of the pigidium. The axial portion is high and tumidly conical and rather obtuse, the marginal sulci being rather deep. The pleural portions are convex and descend rapidly peripherally to the plane of the wide, convex, smooth border which is unmarked or ornamented with concentric striations. The axial segments are ten or eleven and are not sulcate, while the eight or nine pleural ribs are distant and prominent and bifurcate toward the outer end. Entire length, 1.80; width, 1.00; axial length of head, .50; entire length, .85; length of pigidium, .70; width of pigidium, 1.00; width of axial lobe of pigidium, .35; width of axial lobe of thorax anteriorly, .40.

Shumard's statement that the margin of the pigidium is concave, was due to the exfoliation of that portion of the specimen. Several of our specimens are in the same state of preservation.

NOTE.—*Phillipsia elliptica*, M. and W. which, by a curious oversight, was omitted from our list, is much more like P. swallovi than the present species. Refer to Pal. Ill., vol. III, p. 460; Plate 14, Fig. 8.

APPENDIX III. Flint Ridge Bryozoa.

BY A. F. FOERSTE.

The following bryozoa, from Flint Ridge and the equivalent strata at Bald Hill, are the result of several days' collecting at each locality. Considering the wealth of bryozoa in the Carboniferous formations of America, the literature is scanty and frequently very unsatisfactory. Hiram A. Prout described about thirty-five species in the Trans. St. Louis Acad. Sci., from 1858 to 1860. James Hall described about eight species, in the Proc. Am. Ass'n. Adv. Sci. in 1857, and three species in the Geo. Rep. of Iowa, in 1858. F. B. Meek, alone and in conjunction with Worthen, published about nine species. Rominger, Dawson, Geinitz, White, Nicholson, and Swallow have each added one or more species at various times. To these, E. O. Ulrich has added about eighteen species in his American Paleozoic Bryozoa, published from 1882 to 1884. To these publications of Mr. Ulrich I am greatly indebted, as will appear throughout the following notes. Until some of the species published by Prout and others are better understood, the work on Carboniferous bryozoa will remain rather unsatisfactory. It is hoped that the following notes will at least not further involve this subject.

RHABDOMESONTIDÆ, Vine.

Ramose bryozoa; cells radiating in all directions from the central axis, of one kind only, tubular, with an expanded aperture, and an angular immature region.

Genus RHOMBOPORA, Meek.

Branches slender; cells radiating from an imaginary central axis; aperture oval, placed at the bottom of concave, rhomboidal or hexagonal "vestibules," the latter separated by spines, frequently arranged in one or more rows along the dividing ridges.

I. Rhombopora multipora, *sp. n.*

(*Plate* VII, *Fig.* 1, *a*, *b*, *c*.)

Branches doubtlessly dividing; in a length of 25 mm. no such division has taken place, but traces in the rock about 10 mm. beyond seem to indicate that some method of branching has occurred. Branches of medium size, 1.4 mm. wide. Cells arranged in diagonal intersecting and in longitudinal rows; at least 7 cells are found in a distance of 2 mm. in the vertical rows, and about 9 cells in the same distance in the diagonal series. About 20 longitudinal rows surround the stem. Mature region of the cells short, strongly deflected laterally, but not reaching the surface at right angles to the same; immature region much longer, departing from the centre of the branch at a low angle, suddenly bending into the mature portion. The vestibule in well preserved regions has sloping sides and an hexagonal oval outline; the ridges separating the cells are rather narrow and are covered with low, indistinct closely arranged granules, which do not seem to be arranged in well defined rows, as in other species of this genus; in worn portions of the specimen the ridges seem broader and lower, and the granules are indistinct, and scattered. Towards the base the vestibule is more inclined, lengthening its outline; at or just within its border there is frequently a low, rounded node, easily overlooked.

From most species of this genus this form may be readily distinguished by the size of the branches and the more numerous cells. *Rh. lepidodendroidea*, *Meek*, has branches 1.75 to 3 mm. wide; from 5.5 to 6.5 cells occupy the oblique rows (using a standard length of 2 mm.). *Rh. crassa*, *Ulrich*, has branches 2.5 to 4.5 mm. wide; from 5 to 5.6 cells occupy the oblique rows. *Rh. persimilis*, *Ulrich*, has branches .88 mm. wide; 4.4 cells occupy the vertical rows, and 8 cells the oblique rows. *Rh. pulchella*, *Ulrich*, has the same measurements as the last. *Rh. armata*, *Ulrich*, has branches perhaps slightly wider than the last two, about 5.5 cells occupy the vertical rows, and 9.5 cells the oblique rows. *Rh. elegantula*, *Ulrich*, has branches 2.5 mm. wide, from 3 to 4 cells occupy the vertical rows, and almost 5 cells the diagonal rows. *Rh. Wortheni*, *Ulrich*, has branches from 1.3 to 2 mm. wide; 6 cells occupy the vertical rows, and almost 9 cells the oblique rows.

The nearest ally of this species in external features seems to be

Rh. lepidodendroidea, Meek. From this it may be distinguished by the following characteristics. The mature region of the cells appears more abruptly inclined to the immature region of the cells; the ridges between the cells are covered with smaller and more numerous granules, these are also present on the slopes of the vestibules, and are not arranged in such well defined rows as in the other species. Meek in his description of the type specimens gives the following measurements: number of cells in .2 inch, measuring longitudinally, 12; number of cells in .05 inch measuring in the direction of the oblique rows, 4. We have specimens from Kansas City which agree very well with these measurements. The Ohio specimens on the other hand present the following measurements: number of cells in .2 inch, measuring longitudinally, 17; number of cells in .05 inch, measuring in the direction of the oblique rows, 6.

Rare at Flint Ridge. (*Multipora* many pores or cells.)

II. Rhombopora lepidodendroidea, *Meek.*

(*Plate* VII, *Fig.* 3. *a*, *b*.)

Zoarium branching, branches about 1 mm. wide, or slightly less. Cells arranged in diagonal intersecting and in longitudinal series. Longitudinally, 6 cells occupy a length of 2 mm; about 13 longitudinal series surround the stem. Vestibule elongated, smooth, sharply distinguished from the intermediate granule-bearing ridges. Granules strong, readily seen even under a low magnifying power, arranged in one, two, or even three rows along the ridges. At one end of the vestibule a low node is frequently seen. The thin, immature portion of the cells curves gradually outward into the mature portion, where the curvature is increased and the walls become decidedly thickened. The stems branch at intervals varying from 15 to 25 mm.

From the western forms of this species which we have seen, the Ohio specimens show several variations. The branches are much narrower, and instead of 4 cells, 5 cells may be counted in a distance of .05 inch. The vestibules also appear more elongated. However the fact that the branches are narrower would perhaps be sufficient to account for the other variations. Its wide geographical distribution is also of interest in this connection. Meek mentions the species from Nebraska, Kansas, Iowa, Missouri, and Illinois. In species of wide

distribution we are accustomed to look for variations, and our specimens are probably the smaller sized form of the same.

Flint Ridge and Bald Hill. Rather common.

III. RHOMBOPORA ———.

(*Plate* VII, *Fig.* 5, *a*, *b*, *c*.)

A fragment showing the same internal features as the last probably belongs to the same species. About 6 cells are found in a distance of 2 mm. in the longitudinal series, and about 8 cells in the same distance in the diagonal series. The apertures are decidedly rhomboid, the ridges bear rounded nodes at their intersections and show faint traces of low granules between the cells. They recall strongly Meek's figures of the type specimens. They seem to us to owe their more decidedly rhomboid character partly to the effects of exfoliation of the outer crust.

CYSTODICTYONIDÆ, Ulrich.

Frond composed of two or more layers of cells, united along their epithecal membranes. Tubular cells with vertical folds or indentations, the remains of the crescent shaped lip. Interstitial spaces occupied by vesicular tissue, not visible at the surface.

GENUS CYSTODICTYA, Ulrich.

Frond composed of two cell layers, branches compressed, dividing dichotomously, with sharp, nonporiferous margins. Cells arranged in diagonal intersecting series, with more or less marked longitudinal series. Interstitial cells arranged in longitudinal series, angular; arrangement more or less disturbed about the cells.

IV. CYSTODICTYA CARBONARIA, *Meek.*

(*Plate* VII, *Fig.* 2, *a*, *b*, *c*.)

Ptilodictya (Stictopora) carbonaria, Meek; Proc. Acad. Nat. Sci. Phil. XXIII., p. 16); Ohio Pal. Vol. II, p. 328.

Fronds dividing dichotomously at intervals from 5 to 15 mm, branches very thin, non-poriferous margin narrow, smooth, or rarely with faint striations. Branches 4 to 4.7 mm. wide, with 9 to 11 longitudinal rows of cells. Cells arranged in diagonal intersecting rows, more or less curved laterally and sometimes separated there by faint grooves. Single undulating striations more less irregular extend

longitudinally between the cell rows. Cells, five in a length of 2 mm, seven to eight rows in the same distance in width.

Meek especially mentions the absence of striations, but the species is very common at the locality he mentions, "Newark, Ohio, Coal-measures," namely, Bald Hill, and well preserved specimens, especially clear impressions, readily show the faint undulating striæ otherwise overlooked.

C. lineata, Ulrich, has a marked longitudinal arrangement of cells, with marked longitudinal ridges extending between the cell rows. The cells are also fewer in number.

C. occellata, Ulrich, has the diagonal series of cells more curved laterally and the separating furrows more marked, forming a distinct feature of specific value. The branches are also wider.

Common at Bald Hill.

Genus, PRISMOPORA, Hall.

Fronds composed of three cell layers, hence triangular, dividing ("dichotomously," Ulrich, and) trichotomously ; sides frequently unequal, concave, margin often serrated. Cells in oblique intersecting rows, approaching the margins in the serrations, distant from the same along the indented area. Interstitial cells in the form of vesicular tissue, not visible at the surface.

V. Prismopora sereata, *Meek.*

(*Plate* VII, *Fig. 6, a, b, c.*)

Ptilodictya (Stictopora) sereata, Meek, 1875, Ohio, Pal. Vol. II, p. 327.
Cf. Ptilodictya triangulata, 1878, White, Proc. Acad. Nat. Sci. Phil. p. 35.
Ptilodictya triangulata, 1879, White, Pal. Papers, No. XI, p. 214.
Ptilodictya triangulata, 1881, White, Appendix, Rep. of 100th Meridian, p. XXIV.
Ptilodictya triangulata, 1883, White, Contrib. to Invert. Pal. p. 131.
Prismopora serrulata, 1884, Ulrich, Am. Pal. Bryozoa, p. 41.

Zoarium dividing; dichotomous branching alone observed, but since the specimens are mostly in casts and never free, it can not be determined with certainty that there was not a third branch. Specimens from Danville, Illinois, found free, are all trichotomously divided as far as we have observed. Branches triangular; the sides sometimes very irregular. The sides are concave, concavity variable, although always distinct. The three edges are all sharp and serrated

with wavy margins. The size of the serrations extremely variable; some of the most prominent seen being 1.4 mm. wide, 4 serrations taking up a length of 9 mm. Cell apertures distinctly lipped on one side, the lips not directed in definite related directions as far as known; the apertures are not arranged in well defined lines, however, some arrangement can always be discovered. Usually this consists in a disposition of the cell apertures in oblique intersecting lines across the sides of the branches; one of these oblique series can usually be readily seen, the other set are sometimes imperfectly developed; when these oblique series are both well developed, longitudinal series are necessarily present, although even in that case these longitudinal lines run somewhat diagonally along the stem. In other words, diagonal rather than longitudinal arrangement prevails. In the serrations the cells are always more compactly arranged. Along the indented portions, however, there is always a crescentic space, variable in size, along which there are no cells, the margin is therefore interruptedly celluliferous. As may be imagined from some of the remarks above, the number of cells is variable. In one specimen 5 cells occurred in a length of 2 mm. Interiorly the cells are surrounded by vesicular tissue, irregularly arranged.

Meek clearly did not understand his own specimens; he did not know that the branches were three-sided, but gave a thickness of .04 inch to his branches, supposing them to be flat. He also failed to notice the distinctly projecting apertures of the cells with irregular lips. White described his species from the Coal-measures at Danville, Illinois, and states in a later publication that the type specimens were obtained from Mr. William Gurley. I therefore applied to Mr. Gurley for specimens he considered authentic, and received all he had. White could not recognize the three-sided branches in Meek's description and so proceeded to describe his specimens as *Pt. triangulata*, and also states that the cells are irregularly disposed at the surface. Specimens at hand, from the original source, however, show the same arrangement of the cells as noted in the Ohio specimens. Indeed, some of the specimens from Danville show the oblique intersecting series very beautifully. It must be remembered, however, that although diagonal intersecting series are considered typical, most specimens are to some extent variations from this type, however, even then they rather present cases of disturbed regularity than typically irregular disposition. The width is stated as varying from 3 to 5 mm; this is broad enough

to include our specimens from Ohio, but the average width of the Illinois is less than that of Ohio forms, and in general the size of specimens seems more variable at the former locality. Later in the Appendix to the Report of Surv. W. of 100th Meridian, Pl. IV, Fig. 2, White figured one of the type specimens. This specimen falls below the minimum width given in the original description, being only 2.5 mm. wide, and is figured with scattered cells, irregularly undulating edges and without crescentic nonporiferous portions regularly occupying the incurved portions of the sides. However, since Fig. 2, e, on the same plate, representing a specimen from Cebolla Creek, likewise omits the crescentic non-poriferous characters of the margin, readily seen in the original specimens, it is to be expected that in a small specimen this feature would be entirely overlooked. At any rate the smallest specimen we have from Danville, which is 3 mm. wide, shows the crescentic non-poriferous characters, the arrangement of cells noted in the Ohio specimens, and a regularly undulating margin, all the characters being readily noted when attention has been once called to the same.

Again, specimens from Chester, Illinois, of larger size, but of the same average width as Ohio specimens, show no variations from the latter in any particular. The same is true of the specimens just referred to from Cebolla Creek, New Mexico, Nos. 4480, 9447, and 9472 of the National Museum collections. In his Pal. Papers, No. XI, White describes specimens from the middle Carboniferous series of Yampa Plateau, N. W. Colorado, which are only 2 to 2.5 mm. wide. We found in them the same crescentic nonporiferous spaces as noted above in specimens from other localities. Finally, Ulrich described a form from Tateville and Grayson Springs, Kentucky. It is in every respect similar to the Ohio forms. He states: "This species is readily distinguished from all other species of the genus known to me by its wavy or serrated margins." The three-sided character of Meek's specimen was unknown; White in his original description failed to mention the indentations of the margin, in his second description they are stated to be merely a little irregular, but in his third description the scalloped character so readily noticed in larger specimens is distinctly stated and in one example figured.

The general features of the species therefore consist in regularly scalloped margins; the serrations are not rounded typically, but are more or less accurately truncated, sometimes even slightly concave,

the serrations decrease in prominence with the size of the specimens; the indentations are bordered by crescentic non-poriferous spaces; these spaces are large and conspicuous in the larger forms, decreasing to narrow, but distinct proportions in the smaller specimens. The specimens from New Mexico, Kentucky and Chester, Illinois, are undoubtedly the same as our Ohio forms. Those from Colorado are readily connected, it seems, by the variable forms at Danville, Illinois. In conclusion, I desire to express my gratitude to Prof. C. A. White, of the National Museum at Washington, for the ready access to the specimens described by him from western localities. The above discussion is designed merely to present a better understanding of this species, from the abundant material which it has been my good fortune to see.

Common at Bald Hill; rare at Flint Ridge.

ACANTHOCLADIIDÆ, Zittel.

Ramose bryozoa, dendroid, pinnate, or forming fenestrated expansions, consisting of strong central stems and smaller lateral branches proceeding from the margins; the latter uniting in fenestrated genera with the branches of adjacent stems. Stems and branches both poriferous on one side only, non-poriferous dissepiments therefore absent.

Genus GLAUCONOME, Goldfuss.

Main stem very slender, branches springing from the stem at large angles, often at almost right angles. Celluliferous face of both main stem and branches with two alternating, longitudinal series of cells. Non-poriferous side longitudinally striated.

VI. Glauconome whitii, *sp. n.*

(*Plate* VII, *Fig.* 4, *a*, *b*, *c*.)

Largest specimen 18 mm. long and 6 mm. wide, evidently not a complete zoarium. The stem is very slender, rounded, and regular in thickness, having a diameter of about .22 mm. On either side are branches, diverging from the stem at an angle varying from 65 to 82 degrees, usually nearer the angle first given. These branches are of two kinds; the smaller kind are very narrow, about .13 mm. wide, and rather short, a millimetre or less is the length of the largest, so

far seen; the larger kind are slightly narrower than the main stems, about 1.9 mm. wide, and are longer than the branches just described, the length of the largest branch so far seen being 4 mm; at a short distance from the main stem these also bear very short minute branches. Along the stem the branches are stationed with some regularity, about 4 branches in a length of 2 mm; three to four small sized branches intervene between those of larger size when the latter occur. At a distance of 1.6 mm. from the stem along one of the branches the minute branches mentioned above begin; these are stationed also at equal distances apart, almost 5 in a length of 2 mm. The cell apertures are distinctly elevated above the surface of the stems and cause irregularity in the surface. There is always a cell at each juncture of a branch with the stem, near the smaller angle; and also one half way between the successive branches along the stem. Since the alternation of the cells is regular, the branches are therefore not strictly opposite, although at first sight they may appear so. The presence and arrangement of cells on stems and branches is similar, excepting that on the smaller branches they are stationed closer together, as might be expected. Five to seven longitudinal wavy striæ mark the poriferous side; two of these, somewhat more prominent and almost continuous, though variable in distinctness, form a sort of median keel between the cell rows. An equal number of striæ mark the non-poriferous side; these are quite straight and are covered with numerous minute granules, scattered, or apparently forming three or four rows along the striæ.

Glauconome trilineata, Meek, is readily distinguished by its larger size, flattened stems and branches, and a median trilineate ridge on the poriferous side which is very characteristic. *Gl. nereidis, White*, differs in its larger size, the comparatively small space between the branches, and in the presence of dimorphous pores upon the poriferous side on the convex area between the regular cells.

Moderately common at Flint Ridge. Named in honor of the U. S. Paleontologist, Dr. A. C. White, through whose courtesy I was permitted free access to the valuable collections in the United States National Museum at Washington.

Genus SEPTOPORA, Prout.

Zoaria fenestrated by the union of the short lateral branches of adjacent stems; cell rows, two; dimorphic pores present. *Synocladia*,

King, is distinguished by the absence of dimorphic pores, and the presence of more than two rows of cells.

VII. Septopora biserialis, *var.* gracilis, *Meek.*

(*Plate* VII, *Fig.* 7, *a*, *b*, *c.*)

Synocladia biserialis (gracilis, suggested), Meek, Ohio Pal. Vol II, p. 326.

Zoarium flabellate, composed of three or four strong radiating stems, forming a net-work by pinnate division, and the union of opposite, short, lateral branches. Intercalated stems, arising from the coalescing of lateral branches, are not unfrequent. All stems increase in size above. Lateral branches short, inclining at angles of 60 degrees or more to the stems, those of adjacent stems uniting, the union rounded, angular, nodose, or slightly produced. Poriferous face with two rows of cells; alternating with these, usually nearer the margin, although sometimes between the cells, are pores of about one-third the size of the cells. The median ridge is narrow, distinctly nodose, nodes not quite as numerous as the cells on either side. Non-celluliferous face, with the sides sloping from a convex median ridge, which sometimes is indistinct, longitudinally striated, striations strongest along the median area. Dimorphic pores very small, situated singly or in pairs at the junction of the branches with the stems, occasionally a few others scattered about in various positions, but not with the frequency or irregularity indicated by Meek in his figures of *S. biserialis* from the Coal Measures of the West.

From *Septopora biserialis*, *Swallow*, this form may be distinguished by the tendency towards the formation of a median ridge on the non-poriferous side, by the regularity of arrangement of most of the dimorphic pores, both on the celluliferous and non-celluliferous sides, and by the more distant stems and branches, forming larger fenestrules. *S. Cestriensis*, *Prout*, referred by E. O. Ulrich to *S. biserialis* as a variety, differs from our form in wanting the dimorphic pores on the celluliferous side, or at any rate in having them much less numerous. Ulrich's studies indicate great variability in this species, and our form would give it also wide geographical distribution.

The measurements in this case are variable and scarcely specific, but a few may here be given of a specimen considered typical. About 8 stems occur in a width of 10 mm; 9 branches occur in the same length. From the *Fenestellidæ* this species will of course be at

once distinguished by the celluliferous character of what might be taken for dissepiments, even if these should unite neatly.

Common at Flint Ridge. (*Gracilis*, slender branches.)

FENESTELLIDAE, King.

Zoaria usually reticulate, poriferous on one side only, branches united by non-poriferous dissepiments or anastomosing; in the latter case there is never a division possible into stems and branches, so that no confusion with the *Acanthocladiidæ* need arise.

Genus CHAINODICTYON, gen. nov.

Zoaria flabellate or perhaps infundibuliform, branches inosculating, forming a loose net-work, the meshes of which are elongated, elliptical, or oval, somewhat variable (as the openings in the fronds of some *Clathroporæ*). Branches flattened, sometimes even concave on the non-poriferous side. Without longitudinal striæ, as far as known, but with very marked lunate striations or rather folds extending across the non-poriferous sides of the branches, similar to the lines of growth seen on the epithecal membranes of *Stictoporidæ*. Cells in oblique intersecting rows which give rise to three less evident, rather irregular, longitudinal series. (*Chaino*, gaping; *dictyon*, net; alluding to the elongated large meshes of the zoarium.)

Phyllopora, the nearest related genus, has rounded meshes; the branches are far less flattened on the non-poriferous side, and are finely striated longitudinally; on the poriferous side the cells have a more regular arrangement into longitudinal rows; it occurs in older paleozoic formations; *Chainopora* may be considered its later representative.

VIII. Chainodictyon laxum, *sp. n.*

(*Plate* VII, *Fig.* 8, *a*, *b*, *c*.)

Meshes elongated, rhomboid, elliptical, oval, ovate, and obovate in the same zoarium, typically elliptical, about 2.5 mm. long and 1.3 mm. wide. Branches narrow, about .3 to .38 mm. wide; the cells are arranged in diagonal rows; longitudinally about 5 cells may be measured along the sides of the branches in a length of 2 mm. The

cells arise near the nonporiferous side, are quite elongated, and reach the surface at a very oblique angle. Longitudinal arrangement of cells is incidental rather than typical and often obscured, whereas the oblique series remain distinct.

Flint Ridge, rare. (*Laxum*, loose meshes.)

Genus POLYPORA, McCoy.

Zoarium flabellate or infundibuliform, poriferous on the inside; branches nearly straight, connected at regular intervals by non-poriferous dissepiments. No median keel on the poriferous side of the branches; from two to six rows of cells.

IX. Polypora fastuosa, *De Koninck.*

(*Plate* VII, *Fig.* 9, *a*, *b*, *c*, *d.*)

Zoarium infundibuliform. Branches dividing dichotomously, rapidly near the centre, then less frequently, becoming straight above. Non-poriferous face with sloping sides, thus leaving a sort of carina along the middle, varying from this to ordinary convexity; the edges of branches acute, frequently more horizontal than the sides of the branches, thus forming a narrow margin along the fenestrules. The dissepiments very prominent, as high as the branches or even exceeding the same, less than a third the width of the branches, narrowly compressed, and consequently carinated. These dissepiments are very characteristic, giving the oval inclosed fenestrules an oblong outline. Branches finely and closely striated longitudinally; dissepiments also striated. Poriferous face convex. Cells arranged in four to six rows, usually four or five rows; the diagonal series however are usually first noticed. Cell apertures small, separated by twice their length longitudinally. The spaces between the cells are longitudinally striated by wavy lines. In another specimen, with the same characteristics on the non-poriferous side, the poriferous face presents larger cells arranged closely together without the intervening striations. The dissepiments longitudinally striated.

The main characters in the identification of this species have been drawn from Dr. Franz Toula, in his descriptions of *Permo-carboniferous fossils from the west coast of Spitzbergen*, 1875, and of the *Carboniferous Limestone Fauna from the Barents Islands, N. W. of Nowaja-Semlja,*

1875. In the latter publication he states of the diagonal arrangement of the cells; "This arrangement is first seen on the branches, when the exterior layer has been removed. This layer, when best preserved, shows distinct longitudinal striations; by abrasion or splitting off, the inner portions of the cells appear arranged as stated above so close to one another that hexagonal outlines arise." And later: "The dimensions of our specimens are very variable; the fenestrated branches named are sometimes broader, sometimes narrower, and in a piece narrower than usual, even 7 fenestrules are found in a length of 10 mm." Apparently the same variations are found in our specimens. The largest has 5 fenestrules and 6 dissepiments in a length of 10 mm., 7 to 9 branches occur in the same distance in breadth. In one of the smaller specimens, 7.3 fenestrules occur in a length of 10 mm. and 10.5 branches in the same breadth. From 7 to 9 cells occupy a length of 2 mm. The fine longitudinal striæ of the poriferous face of the dissepiments are mentioned by Toula in his descriptions.

Common at Flint Ridge and Bald Hill.

Perhaps we have confounded two species in the above description, one smaller than the other, or with smaller and more distant cells, but we fail to find definite specific characters.

Genus FENESTELLA, Lonsdale.

Differing from *Polypora* in the presence of a median keel, the cells being arranged in two rows, one on either side of the keel.

X. Fenestella limbatus, *sp. n.*

(*Plate* VII, *Fig.* 10, *a*, *b*, *c*, *d*.)

In the limestones at Flint Ridge and Bald Hill are found numerous specimens belonging to the genus *Fenestella*, all of which have the following features in common. The zoaria are infundibuliform; the inner side is poriferous; the median keel is well developed and distinct, along the summit it is occupied by a single row of rounded nodes stationed at regular distances apart, and calling to mind such *Polyporæ* as may be typified by *Polypora submarginata*, *Meek*, for instance, (Pal. East. Nebr. Meek, 1872); the nodes often appear hollow, where abraded, but never alternate with small pores as in the species just cited. The nodes are somewhat more numerous than the cells. Another equally characteristic feature is the form and arrangement of

the cells. Typically one cell is placed at each corner of the fenestrule at the junction of the dissepiments with the branches, another cell is situated on each side of the fenestrule half way between the two cells already located; the number of cells is therefore typically twice that of the dissepiments; but occasionally two cells may fall in this intermediate region and the next cell is thrust to a position just above the next dissepiment, but the typical distribution is easily recognized in the complete individual. The cell mouths are very large, so that the corners of the fenestrules are rounded and near the middle they are constricted, giving a very peculiar appearance to the fenestrules. The broad cells thus give the branches a very characteristic appearance which is suggested in the specific name *limbatus*, bordered.

Here all similarity ceases. The specimens vary from small, fine, delicate forms, to those which are quite coarse. It seems bold almost to associate such forms under one specific name, but we fail to find specific characteristics, although we have abundant material and prefer to designate one well-defined species, to naming several which intermediate forms refuse to admit. Considering them as one species we have the following description of the non-poriferous side. Dissepiments from one-fourth to almost one-half the size of the branches. Fenestrules oblong, the corners angular, varying to coarsely granular, then often with quite large granules in distinct longitudinal rows, often longitudinally striated, especially in worn specimens. Branches from 10 to 13 in a width of 5 mm., dissepiments 9.5 to 13 in the same length.

As types of this species we take the smallest specimens.

XI. Fenestella limbatus, *var.* remotus.

(*Plate* VII, *Fig.* 11.)

A variety having all the other features of this species differs only in having the dissepiments relatively farther removed from each other as shown by the following measurements: 10.5 branches occupy a width of 5 mm, 6.5 dissepiments occupy the same distance in length.

Found with the above.

MONTICULIPORIDÆ, Nicholson.

Zoarium with tubular cells, which are thin walled and polygonal below, above they are bent more decidedly towards the surface, are of nearly equal size throughout, more or less thickened and rounded, but never lipped nor separated by vesicular tissue. Zoarium occasionally frondose, but never composed of two distinct layers of cells entirely separated by the epithecal membranes. A distinct section of this family typified by the following genus will no doubt soon be separated from the same and made an independent family.

Genus STENOPORA, Lonsdale.

Zoarium ramose. Cells of the mature region more or less annulated periodically, with large spiniform tubuli at the angles and straight diaphragms, frequently operculate. Species often erroneously referred to *Chætetes*.

XII. Stenopora Ohioensis, *sp. n.*

(*Plate* VIII, *Fig.* 12, *a*, *b*, *c*, *d*, *e*.)

Branches sub-circular dividing at intervals of about 30 mm. showing faint traces of bilateral arrangement in the immature region. In the immature region the cell walls are thin and polygonal. In the mature region the cell walls become strongly and closely annulated by periodical thickenings, crossed by thin diaphragms at the annulæ. Spiniform tubuli of large size occupy the cell angles, others of smaller size are found on the intermediate cell walls, encroaching below upon the cell cavities as vertical ridges. Well preserved specimens show operculate mouths. Cells irregular in size, the smaller more angular, but not distinguishable in vertical section. About 10 cells occupy a length of 2 mm; branches 5.6 mm. thick.

Locality and position. Flint Ridge.

XIII. Stenopora carbonaria, *Worthen.*

(*Plate* VIII, *Fig.* 13, *a*, *b*, *c*.)

Branches of larger size than the last, 8.9 mm. thick. Cell walls not distinctly annulated; cells larger, crossed by more distant diaphragms, operculate, operculæ visible both in cross and vertical sections, also in hand samples. Large spiniform tubuli at most of the angles of the cells, intermediate spiniform tubulæ wanting. Some

specimens indicate interrupted growth in the zoarium. About 7 cells occupy a length of 2 mm.

Locality and position. Bald Hill and Flint Ridge.

Among the Flint Ridge collections corals are exceedingly rare and only one species has so far been recognized, belonging to the following genus.

Genus CYATHAXONIA, Michelin.

Single polyp cells, with diaphragms, the invaginated centres of which form a solid central axis, the cristiform columella. Radial lamellæ well developed, terminating as superficial carinations on the conical centre of the diaphragms. (Rominger, Fossil Corals, Geol. Surv. Mich. Vol. III, p. 96).

Cyathaxonia prolifera, *McChesney*.

(*Plate* VIII, *Fig.* 15, *a*, *b*, *c*.)

Coral conical, nearly straight, or curved below; epitheca thin, marked by distinct vertical ridges locating the apertural and lateral gaps distinctly; calyx nearly circular, deep; radial lamellæ 20–28, beginning as carinations at the mouth of the calyx, slowly enlarging below and ending as ridges on the invaginated diaphragms; alternating with these lamellæ are carinations or secondary lamellæ, which reach scarcely more than half the distance down the calyx, and therefore are seen only in well preserved specimens; the columella compressed laterally, the larger axis in line with the apertural and central gaps, very prominent.

Largest specimen so far found 22 mm. long, and 17 mm. wide at the mouth of the calyx; the calyx is 13 mm. deep, the columella protruding into the same for a distance of 7 mm; the columella is 2.7 mm. wide below, and about 1 mm. thick. The columella is not always so well preserved.

Locality and position. Flint Ridge and Bald Hill.

During the publication of these pages I learned that Mr. E. O. Ulrich was engaged on a similar list of bryozoa from the base of the Coal Measures at Seville, Illinois, for the Illinois Geol. Surv. Vol.

VIII. From his copious notes on the specimens submitted to him for examination, most of the following are extracted.

Rhombopora multipora, n. sp, is found at Seville, Ill.

Glauconome, Goldfuss, is a synonym for *Vincularia, DeFrance,* having been originally used to designate Mesozoic species of the latter genus; our species must therefore be referred to *Pinnatapora, Vine.*

Pinnatopora Whitii, n. sp, is closely related to *P. bellula, Ulrich,* from Seville, differing in the possession of a double ridged median keel on the celluliferous side, and in the absence of distinct granules forming single rows on the striæ of the reverse, 4.3 cells occur in the same distance as 3 cells in *P. bellula, Ulrich.*

Septopora biserialis, Swallow; a form resembling the western types of this species as figured by Meek, is found at a horizon about 100 feet above the Flint Ridge layer, near Brownsville. The branches are more or less wavy, rounded on the non-poriferous side, the dimorphic pores quite numerous, one or two stationed at the junction of the stems with the branches, the rest scattered. The dimorphic pores of the celluliferous side appear usually between the cells, rather than just without the line formed by them, as is more commonly the case in *S. biserialis, var. gracilis.*

Chainodictyon laxum, n. sp, is also found at Seville, Illinois. Generically, the following cell structure is of importance. Arising near the reverse side of the bryozoum the cells are at first somewhat decumbent, then they enlarge, become compressed laterally, and bend towards the celluliferous surface, opening upon the same as elongated oval or elliptical cells more or less bounded on each side by single longitudinal wavy striæ.

Fenestella limbata, n. sp, is very closely allied to *F. mimica, Ulrich,* as figured in the forthcoming Illinois report, pl. LII, fig. 7. The median keel of the Ohio specimens, however, is more prominent and distinct than in that species, but not at all as large as the median keel of *F. Wortheni, Ulrich,* fig. 5, of the same plate.

Fenestella remota, n. sp. (*F. limbata, var. remota, ante*), proves on further examination to be a well marked species, with four cells to each fenestrule, a comparatively broad median keel occupied by a closely arranged series of nodes. The reverse is occupied by distinct longitudinal striæ.

Plate VII.

Fig. 1. *Rhombopora multipora, n. sp;* a, type; b, part of the surface, X 14; vertical section, X 4.5.

Fig. 2. *Cystodictya carbonaria, Meek;* a, frond; b, part of the surface, X 6. 5; c, cross-sections showing indented cells and angular interstitial cells, X 6.5.

Fig. 3. *Rhombopora lepidodendroidea, Meek;* a, fragments; b, part of the surface, X18.

Fig. 4. *Pinnatopora (Glauconome, ante), Whitii, n. sp;* a, type; b, celluliferous side, X 10; c, non-celluliferous side, X 11; d, section showing internal arrangement of cells, X 11.

Fig. 5. *Rhombopora ? lepidodendroidea, Meek;* a, part of the surface, X 8; b, section; c, the same, X 3.5.

Fig. 6. *Prismopora sereata, Meek;* a, cast, trichotomously dividing at one corner; b, surface; c, cross-sections; d, specimen from Danville, Illinois, dividing trichotomously, with cross-section; e, a side of another specimen.

Fig. 7. *Septopora biserialis, var. gracilis, Meek;* a, non-celluliferous side; b, the same, X 4.2; c, section showing position of cells and dimorphic pores of the celluliferous side, X 8.

Fig. 8. *Chainodictyon laxum, n. sp;* a, zoarium; b, non-celluliferous side, X 3; c, cells, surface view, X 15, and lateral views, X 5.

Fig. 9. *Polypora fastuosa, De Koninck;* a, non-celluliferous side; b, the same, X4; c, celluliferous side, X3, a part, X8; d, another species, a part, X4.

Fig. 10. *Fenestella limbata, n. sp;* a, type; b, celluliferous side, X 11.4; c, non-celluliferous side, X 12.3; d, larger form; e, view of a branch, X 13.

Fig. 11. *Fenestella remota, n. sp. (n. var. ante);* a type; b, cast, X 13.

Fig. 12. *Stenopora Ohioensis, n. sp;* a, part of the surface, X 16; tangential section, X 9.5; the same, X 20; d, vertical section of mature portion showing cross-section of annulæ with their connecting cell-wall and diaphragms, also a lateral view of the annulations and three of the vertical thickenings of the cell-wall, which in tangential sections appear as darkened spots in the cell walls, X 12, also a part enlarged, showing that the walls of contiguous cells are not divided from each other, X 18; e, piece of a branch with cross-section showing tendency towards bilateral structure.

Fig. 13. *Stenopora carbonaria, Worthen,* a, part of the surface, X 12; b, tangential section with traces of operculate diaphragms, X 12; c, vertical section indicating periodical growth, with diaphragms interrupted by operculæ, X 12.

Fig. 14. *Phillipsia Shumardi, Herrick;* a, entire specimen; b, detached movable cheek.

Fig. 15. *Cyathaxonia prolifera, McChesney;* a, lateral view; b, section passing through longer axis of columella; c, view of calyx showing columella. (Plate II, Fig. 21, internal cast of calyx.)

Fig. 16. *Septopora biserialis, Swallow;* a, part of a zoarium; b, non-celluliferous side, X 6; celluliferous side, X 7. Specimen found half a mile west of Brownsville, 100 feet above the horizon of Flint Ridge specimens.

II.

THE CLINTON GROUP OF OHIO. PART II.

BY A. F. FOERSTE.

CRUSTACEA.

I.	Acidaspis Ortoni,	n. sp.
II.	Proetus determinatus,	n. sp.
III.	Proetus ————,	
IV.	Illænus Daytonensis,	Hall and Whitfield.
V.	Illænus Madisonianus,	Whitfield.
VI.	Illænus ambiguus,	Foerste.
VII.	Calymene Vogdesi,	n. sp.
VIII.	Ceraurus ————,	
IX.	Lichas breviceps,	Hall.
X.	Phacops pulchellus,	n. sp.
XI.	Dalmanites Werthneri,	Foerste.
XII.	Encrinurus Thresheri,	n. sp.

In the first paper of this series two new species of trilobites were published and a provisional arrangement of the others was made. Since its publication fresh material has been accumulating and a wider literature has been examined, so that many things then left undecided can now be definitely determined. The following pages may therefore be considered a revision.

Genus ACIDASPIS, Murchison.

I. Acidaspis Ortoni, *n. sp.*

(*Plate* VIII, *Fig.* 1.)

Acidaspis ————, D. U. Bull., Vol. I, p. 101, pl. XIII, fig. 23.

Head semi-circular in outline, moderately convex in the regions of the glabella, suddenly depressed along the movable cheeks, the general effect being to give the head a very convex appearance.

Glabella complex in structure, three-fourths as long as broad; mesial lobe oblong, its length equal to twice the breadth, with three lateral pairs of lobes; the first pair very small, and near the obtuse anterior border; the second pair of moderate size; the last pair large, oblong, occupying almost half the length of the mesial lobe; the two posterior pairs of lobes distinctly separated from themselves and the fixed cheeks by furrows, from the mesial lobe by deep grooves. Fixed cheeks provided with a furrow extending from the posterior part of the eyes to the anterior part of the glabella, cutting from the fixed cheek a lanceolate strip, the pointed end of which lies against the anterior border of the middle pair of lobes; along this furrow, beginning at the eye, extends a narrow ridge almost to the anterior pair of lobes. The facial sutures anterior to the eyes begin the ridges just described, and then gradually separate from the same, cutting the anterior margin of the head with about the same curvature that the corresponding part of the ridge possesses; posterior to the eyes they extend in a curve laterally, then posteriorly to the posterior border of the head at a point slightly removed from the postero-lateral spine. Occipital ring separated from the glabella by a groove, of large size, laterally becoming depressed and attenuated, terminating at the groove which separates the posterior pair of lobes from the fixed cheeks.

Movable cheeks with a raised border along the lateral edge from which a number of spines (about ten) extend; at the postero-lateral edge is quite a long spine; from this spine a border extends along the posterior margin of the head, gradually becoming attenuated until it almost reaches the end of the occipital ring. Owing to the sudden and very great depression of the posterior lobes and fixed cheeks along the posterior border of the head, and the position of the occipital

groove, the occipital ring seems to extend quite a little distance beyond the posterior border.

A glabella figured by F. B. Meek, in Shumard's Reports for the Geological Survey of Missouri, for 1855, from the Cape Girardeau Limestone, *Acidaspis Halli*, is a similar species, although much smaller.

Length of glabella in one specimen of moderate size, 8 mm; including the occipital ring, 11 mm; breadth of the mesial lobe, 4.6 mm; including the posterior lobes, 11 mm, between the inner margin of the eyes, 15.3 mm, between the postero-lateral margins, 21 mm; convexity of the head, 5 mm.

Named after Prof. Edward Orton, the distinguished State Geologist of Ohio.

Locality and position. Brown's Quarry, two miles west of New Carlisle, Ohio, Clinton Group.

Genus PROETUS, Steininger.

II. Proetus determinatus, *sp. n.*

(*Plate* VIII, *Figs.* 2, 3, 3*a*.)

Bathyurus ———, D. U. Bull., Vol I, p. 103, pl. XIV, fig. 5.

Glabella conical, convex, sharply defined from the remaining portions of the head by a distinct furrow; obscurely marked by three pairs of grooves; the posterior pair being inclined at an angle of forty-five degrees to the axis of the glabella, cutting off the postero-lateral corners; the middle pair, although shorter and less inclined, are still fairly distinct; the anterior pair are very indistinct, quite short, and but slightly inclined; in addition three very indistinct pairs of pits may be seen, the two anterior pairs are at the ends of the two anterior pairs of grooves, the posterior pair are opposite the middle of the posterior grooves. In the very distinct occipital furrow beneath the postero-lateral corners of the glabella are two almost triangular tubercles which add to the conical appearance of the glabella. The occipital ring, broad at the middle, narrow at the ends, is supplied with a distinct granule near the centre.

The anterior margin of the head is curved downwards, giving this portion of the head a distinctly convex appearance; the edge is narrow, but plainly elevated at an angle of perhaps forty degrees with those parts of the anterior margin immediately adjacent. The palpe-

bral lobes are rounded, and are situated opposite the anterior half of the posterior furrows. The facial sutures anterior to the palpebral lobes curve slowly outward toward the anterior edge, then suddenly inward again cutting the edge beyond a line passing through the lateral edge of the tubercles.

In this genus the facial sutures behind the eyes are parallel for a short distance, then curve outward and reach the posterior border of the head, usually at a point half way between the glabella and the postero-lateral margin of the head. In *Cyphaspis* the posterior furrows become deep grooves, dividing the glabella into three distinct lobes, of which the central lobe is obovate in form. The middle and anterior furrows are usually wanting. The tubercles found in the Ohio species have not this signification, but are caused by the bifurcation of the occipital furrow.

Length of smaller specimen, glabella, 3.5 mm; including anterior margin, 5 mm. Breadth of glabella, 3.1 mm; including palpebral lobes, 4.5 mm; width measured between the antero-lateral margins of the area anterior to the glabella, 4.5 mm. Length of the larger specimen, glabella, 7 mm; including occipital ring, 8.2 mm; including also anterior margin, 10 mm. Width of glabella just above the tubercles, 7 mm.

Name signifies *bounded, outlined, the limits established,* and refers to the distinct outline given to the glabella by the surrounding furrow.

Locality and position. Soldiers Home, near Dayton, Ohio. Clinton Group.

III. Proetus ————.

(Plate VIII, Fig. 5.)

Fragments of the glabella of a species are found which are readily seen to be distinct from the species just described, but which do not admit of a definite determination. There is no distinct, flat border anterior to the glabella; instead, the broad groove lies close to the glabella anteriorly, separating from the same laterally, and defining the raised rim along the anterior edge of the head. This rim makes an angle of 45° with the adjacent parts of the head. Only one set of grooves is distinctly visible and that is the pair along the postero-lateral margins of the glabella. They begin within the anterior portion of the palpebral lobes and are directed backwards and inwards at the

same time. Tubercles and posterior parts of the glabella are unknown.

Length of glabella, 3.5 mm, including the rim, 4.7 mm; distance between edges at junction of facial sutures with the anterior outline of the head, 3.7 mm.

Locality and position. Brown's Quarry. Clinton Group.

Genus ILLÆNUS, Dalman.

IV. Illænus Daytonensis, *Hall and Whitfield.*

(*Plate* VIII, *Figs.* 6, 7.)

At Brown's Quarry a head of this species was found by Prof. W. S. Hoskinson, of Wittenberg College, which presents the movable cheeks and the rostrum in position. Unfortunately the postero-lateral regions of the movable cheeks are broken off. The character of the rostrum may be easily seen from the figure. The facial sutures extend along the anterior border of the head, of which the rostrum appears a continuation. The movable cheeks become attenuated anteriorly and take a twist which gives their surface a direction in the same plane with the rostrum, against which their tips are accurately fitted.

Locality and position. Soldier's Home Quarries, Brown's Quarry, Ludlow Falls (movable cheek and part of a glabella), Fair Haven (a pygidium), Fauver's Quarry (a pygidium). Clinton Group.

In Ohio this species is the most widely distributed and most characteristic form of the Clinton Group. It would be interesting to know if this is also the case in Wisconsin and Illinois, where similar specimens are said to occur (Ohio Pal. Vol. II, p. 120).

I have seen this species in the collections of the Central Park Museum, labeled Hamburg, Illinois.

V. Illænus Madisonianus, *Whitfield.*

(*Plate* VIII, *Figs.* 8, 9, 10, 10a.)

Since the publication of the last paper little has been added to the knowledge of this species. In that paper two specimens were described. The first pigidium from Huffman's Quarry was very convex and had the anterior edge arching decidedly forwards. The other specimen from Stolz's Quarry was much flatter, broader and less arching anteriorly. At Brown's Quarry numerous pygidia are found, which

approach the latter specimen, although sometimes quite convex and more or less arched anteriorly. Associated with these pygidia are glabellæ, which would be referred to *Illænus ambiguus* without hesitation, if the corresponding pygidia were found. However the following slight distinctions may be discovered. The anterior margin is less curved, the curve of the facial suture anterior to the palpebral lobe is less marked, the glabella is less convex, especially along the median line. All of these characters in themselves would hardly give rise to a new species. Whether there are two species with different pygidia, but very similar glabellæ, is unknown. If not, the glabellæ of Brown's Quarry must be referred to *Illænus ambiguus*. Lieut. A. W. Vogdes writes to me, as Prof. Whitfield's opinion, that the pygidia are related to those of *Illænus insignis*, *Hall*, as figured in N. Y. Report of State Cab. 20. But these evidently do not belong to the glabella which typifies the species. Hence in either case the affinity of the pygidia of Brown's Quarry remains undecided. More material is perhaps necessary to determine this question definitely.

Locality and position. Huffman's Quarry, Stolz's Quarry, Brown's Quarry, Clinton Group.

VI. Illænus ambiguus, *Foerste.*

This species was founded upon a number of pygidia and glabellæ which have a wide range and are usually found associated together. In the first paper, figure 10c, of plate XIV, is inaccurate, representing the upper length of the grooves as being very distinct, whereas in reality this part is very faint and the pits at the extremity of the grooves seem to be isolated, if the glabellæ be not carefully examined.

Locality and position. Soldiers' Home Quarries, Fauver's Quarry (pygidium and fragment of glabella), Fair Haven (pygidium). Clinton Group.

A hypostoma, not very unlike that figured by Billings under *Asaphus Pelops*, is found at the Soldiers' Home (Plate VIII, Fig. 11). I am uncertain with what Clinton forms to place it. It is certain at least that the hypostomæ of the genus Illænus figured by Gerhard Holm, in his work on the Swedish species, are very unlike the hypostoma in question.

Genus CALYMENE, Brongniart.

VII. Calymene Vogdesi, *sp. n.*

(*Plate* VIII, *Figs.* 12, 13, 14, 15, 16.)

Calymene Blumenbachii? Brongniart, D. U. Bull., Vol. I, p. 110, pl. XIII, fig. 25.

Calymene ———. D. U. Bull., Vol, I, p. 109, pl. XIII, fig. 24.

Calymene Clintoni, Vogdes, 1882, Acad. Nat. Sc., Phila., Proc., p, 178, fig. 3.

Head semi-circular, moderately convex. Glabella with three lateral pairs of lobes; the posterior pair triangular-oval and well defined; the middle pair half the size of the latter; the anterior pair small. Glabella depressed towards the occipital furrow, defined from the anterior half of the fixed cheeks by very deep furrows which merge into a groove, defining the anterior part of the glabella, and separating it from the anterior border. Palpebral lobes slightly anterior to the middle lobes of the glabella. Fixed cheeks and adjacent parts of the movable cheeks, greatly elevated, curving rapidly downwards towards the sides and furrowed along the border by a deep, broad groove, which, anterior to the fixed cheeks, merges into the grooves defining the glabella. Just in front of their junction a low tubercle is seen on either side of the border.

The anterior border is quite long, about one-third the length of the glabella, depressed posteriorly along the glabella forming a groove, otherwise quite flat, not arched in the middle, and elevated at a slight angle above the plane formed by the base of the head. Facial sutures parallel anterior to the eyes along the fixed cheeks, then curving slightly outward and inward again to the anterior edge of the head.

Thorax trilobate; the mesial lobe convex; lateral lobe broader, at first horizontal, then curved backwards and downwards; pleuræ grooved anteriorly, about one-third of the pleura lying in front of the groove; extremities of the pleuræ unknown.

Pygidium strongly curved, almost semi-circular anteriorly, moderately curved posteriorly, almost straight behind the mesial lobe. Mesial lobe tapering posteriorly; the anterior portions indefinitely known on account of the broken condition of the specimen, but apparently there is a half segment, followed by six segments, terminating in a wedge-shaped piece, rounded behind and equal in length to the last three segments. Lateral lobes with segments strongly curved to conform with the ante-

rior and lateral margins of the pygidium, the last pair bordering upon the grooves which divide the mesial from the lateral lobes. The last pair of lobes, together with the posterior border, give the mesial lobe the peculiar appearance of terminating in a box, or rather an enclosure which is bounded on two sides by raised lines almost parallel, and on the third side by the posterior outline of the pigidium.

The size is readily enough obtained from the figures and from the description of the form formerly described under *C. Blumenbachii.*

Associated with these specimens are others of smaller size, described under a separate heading in the first paper, but now believed to be identical. They vary from the typical forms in possessing a less distinct groove along the anterior edge of the glabella, the groove almost merges into the flattened surface of the anterior border, the tubercles at the junction of the lateral and glabellar furrows are scarcely visible, often obsolete and the border appears raised at a somewhat higher angle. However, it is now believed that the larger specimens present the features of the smaller forms in a very marked degree, magnifying their characteristics so as to seem distinct.

Lieut. A. W. Vogdes finds a form at Catoosa Station, also in the Hematitic bed at Dug Gap, Clinton Group, Georgia. This he identified with *Calymene Clintoni, Vanuxem.* Expressing the belief that the Ohio specimens should be referred to the same species, he requested the loan of my specimens, and sent me his in return. The identity of his specimens with mine is apparent. The anterior border has been flattened down by pressure, the groove anterior to the glabella is thus made indistinct, the irregularities of the border immediately in front of the groove appear as indistinct low tubercles, or rather an uneven raised line is formed defining the groove immediately anterior to the glabella.

Since Lieut. A. W. Vogdes had access to the type specimens of *Calymene Clintoni,* at the Am. Mus. of Nat. Hist., Central Park, N. Y. and I doubted the identity of Ohio forms with these, I requested him to compare the specimens, and give me an expression of his opinion. He did so very kindly and thoroughly. Considering the very great similarity of the species of Calymene, and the synonomy to which this leads, it is considered desirable to distinguish a new species carefully from all others with which it might be associated. The following notes are therefore extracted from the correspondence of Lieut. A. W. Vogdes.

The first is the well known *Calymene Blumenbachii* of the Wenlock Series of England. The forms of this species represented by Salter (Paleont. Soc. Vol. 1863, pl. 8, figs. 7–16; pl. 9, figs. 1–5, var. Auctorum), approach the American species. The head represented on plate 9, fig. 1, from the Lower Wenlock Grits (Niagara Series), shows a wide frontal margin similar to the Ohio and Georgia forms; the head figured on plate 9, fig. 1a, has a straight anterior margin with a narrow limb, whereas the American forms have this part rounded with a comparatively broad limb. The pygidia figured by Salter, plate 8, fig. 8c, and plate 9, fig. 1b, have a general similarity, although the Ohio forms show a tendency to extend their side ribs more to the rear, giving the pygidium a semi-circular outline.

The Bohemian Upper Silurian form described by Barrande (Syst. Sil. Boheme, Vol. I, pl. 19, figs. 1–19, *Calymene diademata*, Etage E) represents a form with a broad frontal margin (pl. 19, fig. 12), thickened and incurved; whereas, the Ohio species has its frontal margin extended, the anterior border of the head forming a broad and even curve about the head, turned slightly upwards and not arched in the middle, the limb being exceedingly broad and separated from the anterior margin of the glabella by a deep groove. Barrande's figure, pl. 19, fig. 18, represents a broadly rounded pygidium, the axis being anteriorly broad, and tapering posteriorly, marked by six axial rings. The sides are marked by five bifid segments. The Ohio species has a semi-circular pygidium, the posterior margin being almost straight. The axis is broad anteriorly and tapers posteriorly to a rounded extremity, marked by nine well defined axial rings. The sides have five bifid segments, and a posterior undivided pair. The anterior segments being extended backwards to such a degree as to form a semicircle.

Angelin's figures of *Calymene spectabilis* (Pal. Scand. pl. 19, fig. 5, Reg. E), which Salter refers to *Calymene Blumenbachii*, lacks the broad frontal margin of the Ohio forms. The pygidium of this species as represented by Angelin's figure shows the common rounded posterior margin of the English species, *Calymene Blumenbachii.*

The American *Calymene Clintoni* is distinguished by the smooth side lobes of the pygidia. It is found in the Niagara Group shales, at Rochester, N. Y., below the falls.

Calymene mammillata, Hall, (Geol. Rep. Wis. 1861, p. 50), from the shales above the Trenton Group, has "its anterior border extended in front of the glabella in a broadly rounded, thickened projection

which is abruptly recurved at the margin and marked on each side by a mammilliform tubercle." Only the largest Ohio specimen shows signs of the tubercles, and the margin of none of the specimens is recurved. It is hoped that with these comparisons the character and extent of this species may cause no trouble.

Named after Lieutenant A. W. Vogdes, who has aided so much in the elucidation of this species.

Locality and position. Allen's Quarry, Soldiers' Home Quarries, Ohio; Catoosa Station, Hematitic bed at Dug Gap, Georgia; Clinton Group.

Genus CERAURUS, Green.

VIII. Ceraurus ———.

(*Plate* VIII, *Fig.* 17.)

This species, known only by a single glabella, is distinct from any known to me in the same series of rocks. However, it is not deemed wise to give it a specific name, since that might only lead to unnecessary synonomy.

Glabella oval, convex, the posterior border inclined to be straight, with three pairs of furrows; the posterior pair are situated about a third of the length of the glabella from the posterior margin of the same, they curve gradually inwards and backwards, causing the glabella to appear lobate. A little in front of the middle of the glabella is the second pair of furrows, which are shorter. In front of these are the anterior furrows, not so decidedly curved backwards. All these furrows appear to consist of two narrow furrows running very close together in a narrow groove. The little trace of the occipital groove remaining indicates that the occipital ring was strongly depressed towards either side.

Locality and position. Brown's Quarry, Clinton Group.

Genus LICHAS, Dalman.

IX. Lichas breviceps, *Hall.*

(*Plate* VIII, *Fig.* 18, 19.)

Since the publication of the first paper, numerous specimens have been found at John Brown's Quarry. The structure of the head is now

better understood, and the following description represents the present knowledge of the same.

Glabella trilobate. The middle lobe broadly rounded anteriorly, laterally deeply incurved and almost parallel, posteriorly produced on either side something like an apothecary's pestle. Lateral lobes long, sub-reniform, lying against the incurved portion of the mesial lobe, bending about the pestle-like base of the latter. Palpebral lobes reniform, the convex side turns outwards, the anterior part attenuated, the inner side depressed and defined from the fixed cheeks by a groove more or less distinct. Fixed cheeks between the eyes and glabella are ovate in form, at the base, however, they extend laterally along the posterior part of the head, the facial sutures cutting the posterior margin of the same. Between the fixed cheeks, the lateral lobes of the glabella, the tips of the mesial lobe, and the occipital ring, lie on either side small laterally extended tubercles, well defined by furrows.

The hypostoma of this species is frequently found. The figure will readily enough distinguish the same.

Locality and position. Brown's Quarry, Soldiers' Home Quarries, Fair Haven (a glabella), Clinton Group.

Genus PHACOPS, Emmrich.

X. Phacops pulchellus, *sp. n.*

(*Plate* VIII, *Fig.* 4, 20, 21.)

Arionellus ———, D. U. Bull., Vol. I, p. 114, pl. XIV, fig. 3,

Head semi-circular, convex. Glabella convex and broadly rounded anteriorly, narrowed posteriorly, marked by three sets of grooves, all of them curved, the convex side being directed upwards or inward. The first set consisting of two pairs of grooves are horizontal, the rest extending from the lateral terminations of the latter upwards and outwards. In *Dalmanites* these pairs become confluent at the adjacent terminations and form the grooves distinguishing the anterior lobe of the glabella, so characteristic of that genus. The second set are also horizontal, the inner ends being directed slightly upwards. The third set separates the anterior portion of the glabella from the remainder, extending across the axis as an indistinct shallow groove. Between the third set and the well defined occipital furrow the glabella becomes suddenly depressed and compressed laterally, forming a sort of pedes-

tal for the anterior portions of the glabella. The eyes are large. The occipital furrow continues as a well defined groove along the posterior margin of the head. The border anterior to the head is narrow. The character of the postero-lateral corner of the same is unknown, but judging from the usual characters of the genus it was probably slightly rounded and destitute of spines. The facial sutures follow closely the anterior outline of the glabella to the palpebral lobes, from the posterior parts of these they proceed laterally, cutting the lateral margins of the head a short distance above the postero-lateral corners. Viewed directly from the front the facial sutures are seen to be slightly depressed along the middle of the anterior edge of the glabella. The same is true of the adjacent rim of the head.

Length of largest specimen found, 6 mm; breadth, about 9.6 mm. Length of glabella to occipital furrow, 5 mm; greatest width, 5.7 mm, width just above the third set of furrows, 3.1 mm. Associated with these forms is a pigidium which is similar to that of *Proetus planimarginatus*, *Meek*, of Ohio Devonian strata, but which is placed here both on account of its relative frequency at the Soldiers' Home and because other species, undoubtedly of this genus, possess similar pygidia.

These pygidia are broad; the curvature of the anterior edge is moderate; the middle lobe is prominent and very convex, ending abruptly posteriorly; segments about nine in a well developed specimen, each segment with a tubercle, these forming a median row. Lateral lobes moderately convex, with seven or eight segments, becoming indistinct posteriorly. Segments all grooved along the middle, that part of the pygidium which lies behind the termination of the middle lobe does not show evident segmentation. Posteriorly the margin is thickened along the edge of the pygidium, so that a groove is formed within the posterior edge leaving a plane margin which vanishes anteriorly.

In *Proetus planimarginatus* the central lobe of the glabella has similar groovings, but the postero-lateral margins are enlarged; there is no flat border between its anterior margin and the groove running along the edge of the head, the tubercles are also smaller and more nearly rounded. The pygidia have the same general form and the same median row of tubercles along the middle lobe, but the groove extends all around the lateral and posterior margin, and leaves a continuous border, from which it derives its name.

Length of pygidium, 7 mm; breadth, 12 mm; width of anterior portion of middle lobe, 4 mm, near the posterior termination, 2 mm; the marginal groove vanishes between the third and fourth segments of the lateral lobes.

Name signifies *small* and *beautiful.*

Locality and position. Soldiers' Home Quarries. Confounded by collectors with small specimens of *Dalmanites Werthneri.* Clinton Group.

Genus DALMANITES, Emmrich.

XI. Dalmanites Werthneri, *Foerste.*

(*Plate* VIII, *Figs.* 22, 22*a*, 23, 24, 25.)

The figures of this species, omitted from the original description, are added here, for readier determination.

Locality and position. Soldier's Home Quarries, Clinton Group.

Genus ENCRINURUS, Emmrich.

XII. Encrinurus Thresheri, *sp. n.*

(*Plate* VIII, *Fig.* 26.)

Pygidium, on account of the great compression and depression of the lateral lobes, is longer than broad. The general form is triangular, highly arched along the entire length of the mesial lobe. Mesial lobe broad anteriorly, becoming gradually attenuated posteriorly, crossed by segments, about 18 in number, becoming indistinct posteriorly. The segments are all more or less interrupted along the mesial line of the lobe, and beginning with the anterior segment, each third segment is supplied with a tubercle, *i. e*, the segments, 1, 4, 7, 10, 13 and 16. The suppression of the middle part of the anterior three segments is less evident. The lateral lobes are marked by seven segments. The anterior segments are directed laterally for a short distance and then are deflected in a broad curve to the rear. The posterior deflection of the succeeding segments becomes more marked until the seventh pair extends in a parallel direction backwards from the mesial lobe. The inner terminations of the interrupted segments of the mesial lobes form low nodules, often indistinct. A similar set may sometimes be distinguished along the edges of the mesial lobe. The seg-

ments of the lateral lobes are narrower than the intervening grooves, and supplied with three or four sets of indistinct nodules.

Encrinurus deltoideus, Shumard, from the Cape Girardeau Limestone, Missouri, may be distinguished by its rounded extremity, its greater number of segments (24) along the mesial lobe, and also along the lateral lobes (8 segments). The segments of the lateral lobes are twice as wide as the furrows between them, and are devoid of nodules.

Encrinurus nereus, Hall, from the Racine beds of Wisconsin, may be distinguished by the greater number of segments (8 or 9) on the lateral lobes, as far as known not tuberculated; judging by the figure of the type specimen a raised narrow, but distinct ridge runs along the lateral borders of the middle lobe.

Encrinurus Americanus, Vogdes, from the Clinton Group of Georgia, may be distinguished by the smaller number of segments (6) along the lateral lobes; the segments are almost twice as broad as the deep intervening grooves, are flat and even slightly grooved along the top, and are destitute of nodules, as far as known.

Encrinurus elegantulus, Billings, from the Anticosti Group of Canada, may be distinguished by the greater number of segments (24) along the middle lobes, the anterior 8 extending entirely across, the rest being interrupted, the free mesial space without tubercles. There are only 5 pairs of segments on the lateral lobes. They agree however in the origin of the segments of the lateral lobes, when compared with the position of the segments on the middle lobe.

Encrinurus ornatus, Hall and Whitfield, from the Guelph limestones of Ohio, may be distinguished (if the figures of the type specimen are correct) by the segments of the lateral lobes having a less abrupt backward direction, and being all situated along the side of the middle lobe (whereas in *E. Thresheri* the seventh pair extend posteriorly from the same). The arrangement of the mesial tubercles along the middle lobe is also different, being situated on the second, fifth, ninth, thirteenth, seventeenth, and perhaps one on a later segment. If now the tubercle on the second segment be omitted the remainder are evidently seen to be separated each time by three segments (instead of by two as in *E. Thresheri*).

Encrinurus punctatus, Wahlenberg, of Sweden and elsewhere in Europe, may be distinguished, it is said, by a single row of nodes along the middle of each lateral lobe (whereas the fourth segment of

the lateral lobes in *E. Thresheri*, shows 4 tubercles, and the anterior segments probably presented more.

Encrinurus punctatus, Hall, from the Clinton Group of New York, if it be identical with *Encrinurus ornatus*, will of course be distinguished by the same characters as those mentioned under that species; the number of tubercles or nodes in the New York and Ohio Clinton specimens and the size of the pygidia, however, agree better than when the pygidia of the New York and Ohio Guelph specimens are compared. At any rate, the Clinton forms are distinct from the typical specimens of *E. punctatus* from Europe, and from the species described as *E. ornatus*, from the Guelph strata of Ohio.

Named after Mr. B. B. Thresher, of Dayton, in whose cabinet the type specimen is found.

Locality and position. Clinton Group.

GASTEROPODA.

Genus BUCANIA, Hall.

Bucania trilobata, *Hall.*

(*Plate* VIII, *Fig.* 33, *a*, *b*.)

Shell convolute, volutions in the same plane, contiguous; laterally compressed. Body of the shell strongly lobed, the dorsum being laterally compressed and thus separated by a sort of groove from the lateral portions of the volution, giving rise to one dorsal and two lateral ridges or lobes. The form of the aperture is not seen in our Ohio specimens, but would naturally conform to the trilobate structure of the last volution.

Authors are inclined at present to abandon the genus *Bucania*, and to place the forms referred to it among the *Bellerophons*. We have seen fit to retain this name in this case purely as a matter of convenience. There is already a species called *Bellerophon trilobatus*, described by Sowerby, in his "Silurian System", a European form. From this our form may be readily distinguished by the lateral compression of its last volution. The European form on the other hand has this volution decidedly flattened transversely, being elliptical in section; the middle lobe is comparatively much broader and not so much elevated above the lateral lobes. Our specimen differs from the New York types chiefly in size, being comparatively exceedingly small.

It may be noted, however, in this connection that it is associated with a number of small fossils, which apparently are depauperate forms of other, well-known species.

Locality and position. Beavertown marl, Huffman's Quarry. Clinton Group.

LAMELLIBRANCHIATA.

GENUS PTERINEA, Goldfuss.

PTERINEA BRISA, *Hall.*

(Plate VIII, Fig. 30.)

Since the description of the specimens from the Soldiers' Home Quarries, a large number of quite perfect specimens have been obtained from Brown's Quarry, near New Carlisle. A very fine specimen, belonging to the cabinet of Prof. W. S. Hoskinson, is here figured.

They are all left valves. The body of the shell is obliquely sub-ovate, extremely inequilateral; the anterior wing is rather long, and distinctly sinuate at its junction with the body of the shell; the posterior wing is acute and extends almost if not quite as far as the posterior extremity of the shell. The umbo is prominent, rising above the hinge-line. The anterior wing is depressed antero-laterally along the hinge-line, giving sometimes the deceptive appearance of a hinge-line strongly bent at the beaks (as in figure 9, plate 28, Geol. Surv. Ind., Eleventh Report). The surface is marked by numerous distinct radiating and concentric striæ.

Our specimens compare very well, as near as we can judge, with the type figured from Bridgeport, Illinois. The Indiana specimens referred to this species have a comparatively greater width, measuring vertically from the hinge-line; the concentric striæ are usually in the form of prominent lamellæ, recurving at their edges, often fimbriated, characters which our specimens never present.

Length of one of the largest specimens, measured from the umbo to the posterior extremity of the hinge-line, 18 mm, to the posterior extremity of the body, 21 mm; width measured from the hinge-line vertically, 14.5 mm.

Locality and position. Brown's Quarry, Soldiers' Home Quarries. Clinton Group.

BRACHIOPODA.

I. Streptorhyncus tenuis, ... Hall.
II. Strophomena patenta, ... Hall.

GENUS STREPTORHYNCUS, King.

I. STREPTORHYNCUS TENUIS, *Hall.*

(*Plate* VIII, *Figs.* 31, 32, 38.)

Shell quite large, semi-circular; cardinal line less than the greatest width of the shell, cardinal extremities rounded. Ventral valve flat, the beak and immediately adjacent portions slightly elevated. In the description of the type specimens this valve is said to be slightly concave. Our valve can not be said to be anything more than flat. Dorsal valve moderately convex, the umbo not prominent; convexity, with the exception of a little compression near the cardinal extremities, regular.

Surface marked by numerous, rounded, radiating striæ, somewhat curved near the cardinal extremities; alternating with these are smaller thread-like striæ. These radiating striæ are crossed by fine concentric striæ, presenting when magnified, a beautiful, rugose appearance. Substance of the shell very thin.

One of the largest ventral valves is 30 mm. long, and 36 mm. wide. Our specimens therefore do not attain the size of the Indiana specimens. A dorsal valve is 22 mm. long, 30 mm. wide, and measures 26 mm. between the cardinal angles; its convexity is about 3.2 mm.

Locality and position. This is quite a common species in one part of the Soldiers' Home Quarry. Clinton Group.

GENUS STROPHOMENA, Rafinesque.

II. STROPHOMENA PATENTA, *Hall.*

(*Plate* VIII, *Fig.* 34, 35, 36, 37.)

Leptæna patenta, Hall, 1852, Pal. New York, Vol. II.
Strophomena patenta, Hall, 1859, 12th Ann. Rep. Cab. Nat. Hist. of New York.
Strophomena euglypha, Roemer, 1860, Sil. Fauna, West. Tennessee.
Strophomena patenta, Hall and Whitfield, 1875, Pal. Ohio, Vol. II.

Shell of moderately large size. At various stages of growth they

present a very different appearance, so as often to suggest distinct species, as may be noticed by the following descriptions.

Ventral valve, length 6.7 mm, width 8 mm. Valve moderately convex, the cardinal extremities compressed, umbo moderately prominent. The corresponding dorsal valve is moderately concave, greatest concavity near the beak.

Ventral valve, length 11 mm, width 14 mm. Valve strongly convex, especially at the umbo which is about one-third the distance from the beak to the anterior margin; the cardinal extremities compressed.

Ventral valve, length 15 mm, width 19 mm. Valve convex especially at the umbo, which is one-fourth the distance from the beak, the anterior, lateral, and postero-lateral extremities flattened or compressed. The corresponding dorsal valve is slightly concave, its greatest concavity being about one-fourth the distance from the beak. The cardinal extremities are quite flat.

Ventral valve, length 18 mm, width 24 mm. Valve with cardinal extremities quite flat: the regions about the umbo, which is one-fifth the distance from the beak, convex; moderately concave beyond the centre, towards the anterior and lateral margins. These margins in the dorsal valve are slightly convex.

Ventral valve, length 25 mm, width 33 mm. Concave in general with a convex umbo, whose greatest convexity lies at about one eighth the distance from the beak. The dorsal valve concave with the anterior and lateral regions moderately convex. This is of the form of the New York specimens which formed the type of this species. These never seem to arrive at the stage presently to be described; the striations are also coarser than those of the Ohio forms.

Ventral valves, length 28, width 35. Valves convex for about half their length, the umbo being very close to the beak, beyond the middle anteriorly and laterally they become strongly recurved, or geniculate in some individuals. The corresponding dorsal valve is moderately concave for half its distance, then strongly bent or geniculate for the remainder of the distance towards the anterior and lateral margins.

Shell marked by numerous, fine, radiating striæ; in young specimens certain of the striæ at more or less regular intervals become more prominent, in the typically strophomenoid manner. In older specimens, the prominence of these striæ no longer is sufficient to attract attention, or is even entirely lost. After the removal of the thin

exterior crust, these striæ often appear as radiating series of papillæ, especially prominent and distinct near the anterior and lateral margins.

Locality and position. Soldiers' Home Quarries, Fauver's Quarry, Centreville. Clinton Group. Also in New York and Tennessee.

GRAPTOLITIDÆ.

I. Dictyonema pertenue, ... n. sp.
II. Dictyonema scalariforme, ... n. sp.

Genus DICTYONEMA, Hall.

I. Dictyonema pertenue, *sp. n.*

(*Plate* VIII, *Figs.* 27, *a*, *b*.)

Frond infundibuliform, composed of numerous slender branches connected at intervals by fine transverse dissepiments, thus forming a fenestrated expansion. The branches are more or less cylindrical in form, about .23 mm. broad, and from 1.3 to 2 times their own width distant from another; they increase by dichotomous division, adjacent branches are parallel, about 9 branches occupying a width of 5 mm. The dissepiments are very fine, about .025 mm. thick; owing to their fineness they can not be readily discovered in all parts of the fronds, nor can their arrangement be accurately determined, but on an average they seem to be about 1 mm. or slightly less apart. Non-celluliferous face marked by strong, short, curved striæ, suggestion the appearance of twisted strands. The celluliferous face has not been seen, however abraded specimens frequently leave impressions of the cells in the rock from which the following characters are drawn up. Cells, circular at their apertures and protruded from the surface of the frond, arranged in a single, straight series along the middle of the branches. The cells are about .18 mm. in diameter, and a little more than their own width apart, about 12 cells occupying a length of 5 mm. The frond from which this description was prepared is a flabellate fragment 23 mm. in length.

The name signifies *very slender*.

Dictyonema pergracile, Hall and Whitfield, is described as a species in which the branches do not exceed .5 mm. Our specimens are only half that size, but since the minimum width in the Kentucky speci-

mens is not mentioned, this can not assist in the identification of our specimens. However the branches of our specimens are not evidently tortuous, nor are the fenestrules elongate hexagonal in form.

Dictyonema splendens, Billings, is said to have "longitudinal stems about one-third of a line wide, and about their own width distant from each other. There are five or six longitudinal stipes in the width of two lines," a very suggestive mathematical problem. Giving it a fair interpretation, there are 5 or 6 branches instead of 8 in a width of 2 lines, and the branches are probably somewhat broader than in our own specimens.

In neither case is any mention of the cells made. All three forms may eventually prove to belong to the same species. At present, however, our form appears a well defined species with close and narrower branches than any hitherto described.

Locality and position. Soldiers Home, near Dayton, Ohio. Clinton Group.

II. Dictyonema scalariforme, *sp. n.*

(*Plate* VIII, *Figs.* 28, 29.)

Frond infundibuliform. Branches of medium size, from once to twice their own width distant from each other, dividing dichotomously and connected by transverse bars or dissipiments one-fourth or one-third their width. The dissepiments are stationed at unequal distances from each other, varying from once to twice the distance between the branches, and leaving quadrangular or oblong fenestrules between the same. The celluliferous side of the frond has not been seen ; in places however where the frond has been abraded the position and the frequency of the cells is distinctly shown. Judging from this, they are placed in a single row along the middle of each branch; there are about 13 cells in a length of 5 mm ; these cells seem to have an oblique upward direction, consecutive cells leaning upon those in front of them, thus forming a narrow ridge or keel; at their tips the cells seem to have become more or less free, and to have developed circular apertures. Non-celluliferous face striated obliquely by short, curved striæ suggesting twisted strands.

Frond here described, a flabellate fragment, 40 mm. long and 35 mm. broad. From 10 to 12 branches occupy a width of 10 mm, and from 10 to 13 dissepiments occupy the same distance in length. The

branches where they are well preserved, are from .5 mm. to .65 mm. wide. The dissepiments vary from .1 mm. to .22 mm. in thickness.

The name signifies *ladder shaped.*

This species is evidently related to *Dictyonema retiforme, Hall,* differing from the same in the narrower branches being more compactly arranged, the dissepiments likewise occurring at shorter intervals. According to Prof. J. W. Spencer the branches of *D. retiforme* are on an average about one millimetre in width. The largest branches of our specimens do not attain this width.

Locality and position. Soldiers' Home, Clinton Group.

Graptolites of this genus usually appear as black strands on the surface of the rock. In this connection it is interesting to note that the cell walls of *Stictopora gracilis, Spencer,* present the same appearance, momentarily suggesting a graptolite.

PLATE VIII.

Fig. 1. *Acidaspis Ortoni, n. sp;* a head, anterior margin unknown.

Fig. 2. *Proetus determinatus, n sp;* a glabella with part of anterior border.

Fig. 3. *Proetus determinatus, n. sp;* a glabella, with attached border and palpebral lobe.

Fig. 4. *Phacops pulchellus, n. sp;* an associated pygidium.

Fig. 5. *Proetus* ————; a glabella with anterior border and palpebral lobe.

Fig. 6. *Illænus Daytonensis, Hall and Whitfield;* rostrum in position, sharp edged postero-lateral margins of movable cheeks broken off; a, a movable cheek, from Ludlow Falls.

Fig. 7. *Illænus Madisonianus, Whitfield;* a glabella, very doubtfully referred here.

Fig. 8. *Illænus Madisonianus, Whitfield;* pygidium, with paraboloid outline.

Fig. 9. *Illænus Madisonianus, Whitfield;* pygidium, somewhat broader.

Fig. 10. *Illænus Madisonianus, Whitfield;* pygidium, semi-circular, not paraboloid.

Fig. 11. A hypostoma, very doubtfully referred to some species of Illænus.

Fig. 12. *Calymene Vogdesi, n. sp;* head of type specimen.

Fig. 13. *Calymene Vogdesi, n. sp;* profile along the middle of the same.

Fig. 14. *Calymene Vogdesi, n. sp;* head of a younger specimen.

Fig. 15. *Calymene Vogdesi, n. sp;* profile along the middle of the same.

Fig. 16. *Calymene Vogdesi, n. sp;* characteristic pygidium.

Fig. 17. *Ceraurus* ————; a glabella.

Fig. 18. *Lichas breviceps, Hall;* a glabella, with part of a fixed cheek.

Fig. 19. *Lichas breviceps, Hall;* a hypostoma.

Fig. 20. *Phacops pulchellus, n. sp;* a glabella. with fixed cheeks.

Fig. 21. *Phacops pulchellus, n. sp;* a head, the cheeks on the right wanting.

Fig. 22. *Dalmanites Werthneri, Foerste;* a head, the spines wanting ; a, a detached spine, seen from below.

Fig. 23. *Dalmanites Werthneri, Foerste;* a pygidium.

Fig. 24. *Dalmanites Werthneri, Foerste;* an almost entire specimen.

Fig. 25. *Dalmanites Werthneri, Foerste;* an eye, magnified.

Fig. 26. *Encrinurus Thresheri, n. sp;* a pygidium, figured a little too narrow.

Fig. 27. *Dictyonema pertenue, n. sp;* a, a frond ; b, part of the same magnified.

Fig. 28. *Dictyonema scalariforme, n. sp;* a frond.

Fig. 29. *Dictyonema scalariforme, n. sp;* a part of the same magnified.

Fig. 30. *Pterinea brisa, Hall;* a right valve.

Fig. 31. *Streptorhyncus tenuis, Hall;* a dorsal valve.

Fig. 32. *Streptorhyncus tenuis, Hall;* a ventral valve.

Fig. 33. *Bucania trilobata, Hall;* a, a lateral view ; b, dorsal view ; both views, X 5.

Fig. 34. *Strophomena patenta, Hall;* a ventral valve of a young specimen, with no distinctly elevated beak, referred here.

Flg. 35. *Strophomena patenta, Hall;* a ventral valve of a young specimen of the normal type.

Fig. 36. *Strophomena patenta, Hall;* a ventral valve at an older stage.

Fig. 37. *Strophomena patenta, Hall;* a dorsal valve, the cardinal angles not acute.

Fig. 38. *Streptorhyncus tenuis, Hall;* a few of the radiating striæ enlarged, showing fine concentric striæ.

Fig. 39. *Ichthyocrinus sp;* a fragment of the calyx.

Figs. 40, 41. Bases of calyces of crinoids, of unknown relation.

Figs. 42, 43. Plates from calyces of an unknown crinoid.

Fig. 44. A specimen of unknown relation, probably a part of some crinoid.

III.

On the Determination of the Horizontal Component of the Earth's Magnetic Force.

BY L. E. AKINS.

The method I have used in the determination of H is the one used at the University of Glasgow. The attractive feature of the method is the simplicity with which the ratio of m to H, and the product of mH are determined, where m is the magnetic moment of a given bar magnet. The apparatus used is a small Bottomley magnetometer and a deflecting bar magnet.

The cut, which is exactly one half full size, fully illustrates the magnetometer, except that the needle needs a little explanation. The one I used consists of two bar magnets about eight-tenths centimetres long and one-tenth centimetre wide, and as thin as the steel can be conveniently worked. The magnets are fastened with shellac, like poles together, to the back of a small mirror and suspended by a single silk fiber as in the cut. I silver my own mirrors, using the short process given in Roscoe's Chemistry, Vol. II. With care in cleaning and by keeping the glass quite warm while the silver is being precipitated, a very good mirror can be obtained. The mirrors I used were small microscope covers five-tenths centimetres in diameter.

The first experiment is to find an expression for $\frac{m}{H}$ which is accomplished as follows. The magnetometer is set up so that its needle is in the magnetic meridian of the place and its centre directly over the point where a line, exactly at right angles to the N. and S. line, cuts that line. A very convenient arrangement for this consists of two boards, each eight inches wide, one five feet long, the other

three, put together in the form of a cross, with the middle of the short board about forty inches from one end of the long board. The boards should be carefully *halved* together and be exactly at right angles to one another. This cross is mounted on a stand so that it can be easily turned in azimuth, and so that the longer part stands nearly east and west. The magnetometer is now placed in the middle of the short arm and adjusted so that the middle line of the short arm and the middle line of the long arm of the cross, exactly at right angles to the former line, intersect directly under the centre of the needle. A scale and lamp should now be arranged in front of the magnetometer, with the scale supported by the longest arm directly in front of the magnetometer, parallel with the line on the short arm and distant one hundred centimetres from the needle. The middle of the scale should be directly over the middle line of its arm. The lamp is placed in front of a hole cut in the scale support directly under the centre of the scale. The light from the lamp is thus reflected back upon the scale. Now turn the cross till the spot of reflected light falls directly on the centre mark of the scale. The instrument is now in its proper position for use.

I find that with a plane mirror I can get the best spot of light by using two lenses, one of long focal length, placed close to the face of the mirror and one of comparatively short focal length placed close to the aperture in the scale support. To obtain a dark line across the spot of light, I place a very fine wire between the two lenses and move it back and forth till the mark is sharply defined across the spot.

The deflecting bar magnet is now placed, end on, in the east and west line, with its centre forty centimetres distant from the needle and the deflection of the spot of light noted. Then the magnet is placed on the opposite side at same distance and deflection noted. If all the adjustments are perfect, these two deflections will be equal; but the mean of them will give nearly enough the true deflection. All the measurements being made with the same unit, the number of scale divisions divided by distance of scale from mirror gives tan $2a$; where a is the angle of deflection of the mirror.

If r is the distance of centre of magnet from the mirror, l the half length of the magnet, m the magnetic moment of the magnet, H the horizontal component, then $\frac{m}{H} = \frac{(r^2 - l^2)^2}{2r} \operatorname{Tan} a$ (1)

The magnet may also be placed in the north and south line, side

on, and deflections taken; then, *r. l. a. m. H.* meaning same as before,

$$\frac{m}{H} = (r^2 + l^2)^{3-2} \operatorname{Tan} a. \quad (2)$$

The magnetometer is now removed, and the bar magnet suspended by a single fiber of silk, where the magnetometer stood. The ingenuity of the experimenter will best find a way for doing this. It is well to fasten a very small mirror to the suspension fiber, so that the period may be observed from the reflected light on the scale. The fiber in this case should be as long as possible to make the error due to its torsional rigidity as near a minimum as possible. If the fiber be twenty centimetres long, the error will be so near to zero as not to practically effect the result. The equation Mr. Gray gives for the determining of T in terms of m and H is $\frac{d^2 a}{dt^2} + \frac{m\ H}{N}\ a = 0$ where N is the moment of inertia of the vibrating system. The solution of this equation can be found in Williamson and Tarlton's Dynamics, art. 107.; or in Dynamics of a Particle by Tait and Steel, art. 88. From this $T = 2\ \pi \sqrt{\frac{N}{m\ H}}$ * For magnets one tenth centimetre in diameter $N = \frac{W\ l^2}{3}$ where W is the weight of the magnet in grammes. Therefore $m\ H = \frac{4\ \pi^2\ l^2\ W}{3\ T^2}$ (3) Combining this with (1) $H^2 = 8\text{-}3\ \frac{\pi^2\ l^2\ r\ W}{T^2\ (r^2 - l^2)^2 \operatorname{Tan} a}$ and with (2) $H^2 = 4\text{-}3\ \frac{\pi^2\ l^2\ W}{(r^2 + l^2)^{3-2}\ T^2 \operatorname{Tan} a}$

The measurements should all be in the metric system and then the value of H is given in c. g. s. units. I find that magnets for deflectors made from No. 18 knitting needles and ten centimetres long give the best results. If wire of a larger diameter is used, a more complicated formula must be used, involving the moment of inertia of a right cylinder about an axis through its centre of gravity and perpendicular to its own axis. The length l is the measured half length of the bar magnet. Mr. Gray gives a method for determiniug the actual effective length of the magnet; but I have not used it. Corrections also might be made for atmospheric resistance to the vibrator, change of length due to change of temperature; but these are so very small that, for practical purposes, they may be neglected.

The angle $2a$ should be so small that $\operatorname{Tan} a = \frac{1}{2} \operatorname{Tan} 2a$. This will avoid much labor in making computations.

As the mean of a considerable number of experiments I find for

H in my study the value .19707 c. g. s. units. Of course the value is always modified by the presence of iron, and I could not eliminate errors resulting from that.

The following from my results of Mar. 28 will help to illustrate the method used:

SIDE ON.

Magnet	Mar	Tan. $\frac{2a}{1000}$	Tan. a	l	r	T	W	H
A	28	$\frac{19.5}{1000}$	.00975	5	35	4.16	.8765 gr.	.1989
B	28	$\frac{20.125}{1000}$	.01007	5	35	4.08	.8682 gr.	.1963
C	28	$\frac{13.875}{1000}$	.00694	5	35	4.706	.8745 gr.	.1987
D	28	$\frac{19.75}{1000}$	.00988	5	35	4.285	9255 gr.	.1953

For further explanation the student is referred to Mr. Gray's book. I make no claim to originality. I have only followed as nearly as possibile the directions given there. I have been so pleased with the method that I have thought others might be induced to try it.

*The symbol Pi is represented by π throughout.

IV.

LIST OF ALGÆ.

BY H. L. JONES.

The following list of Algæ is made up from specimens collected at the Licking Reservoir and from ponds in the vicinity of Granville. Only a very few of the most common species are here given, with the exception of the desmids, the list of which is somewhat more complete.

Spirogyra Weberi, Ktz.,

Spirogyra insignis, Ktz.,

Scenedesmus polymorphus, Wood,

Scenedesmus quadricauda, Breb.,

Pediastrum simplex, Meyer,

Pediastrum Ehrenbergii, A. Br.,

Pediastrum Boryanum, Turpin,

Pediastrum angulosum, Menegh.,

Cosmarium Brebissonii, Menegh.,

Cosmarium contractum, Kirch.,

Cosmarium Seelyanum, Wolle,

Cosmarium intermedium, Delp.,

Cosmarium Botrytis, Menegh.,

Cosmarium latum, Breb.,

Cosmarium Broomei, Thwaites,

Cosmarium orbiculatum, Ralfs,

Cosmarium Ralfsii, Breb.,

Cosmarium tinctum, Ralfs,

Cosmarium biretum, Breb.,

Micrasterias truncata, Ralfs,

Desmidium Swartzii, Ag.,

Sphaerozosma filiforme, Rab.,

Closterium moniliferum, Ehrb.,

Closterium Dianæ, Ehrb.,

Closterium parvulum, Naeg.,

Closterium strigosum, Ehrb.,

Closterium lineatum, Ehrb.,

Staurastrum polymorphum, Breb.,

Staurastrum pseudopachyrhynchum, Wolle,

Staurastrum inconspicuum, Nord.,

Staurastrum anatinum, Cooke and Wells,

Dociduum Trabecula, Naeg.,

Euastrum elegans, Breb.,

Euastrum rostratrum, Ralfs,

Ktz.—F. T. Kuetzing; Breb.—A. de Brebisson; A. Br.—Alex. Braun; Menegh.—J. Meneghini; Kirch.—O. Kirchner; Delp.—J. B. Delponte; Ag.—C. A. Agardh; Naeg.—C. Nageli; Nord.—O. Nordstedt.

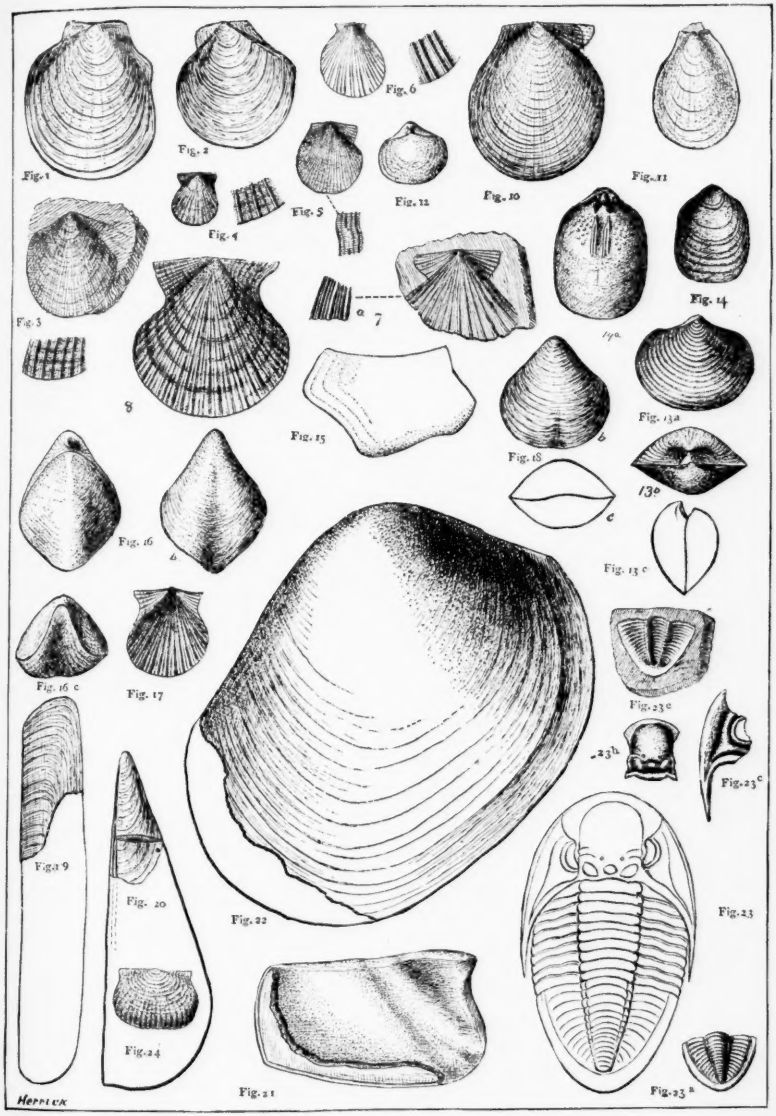
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Fig. 18
Fig. 13a
Fig. 13b
Fig. 16
Fig. 13c
Fig. 16c
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Fig. 23c
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Fig. 24
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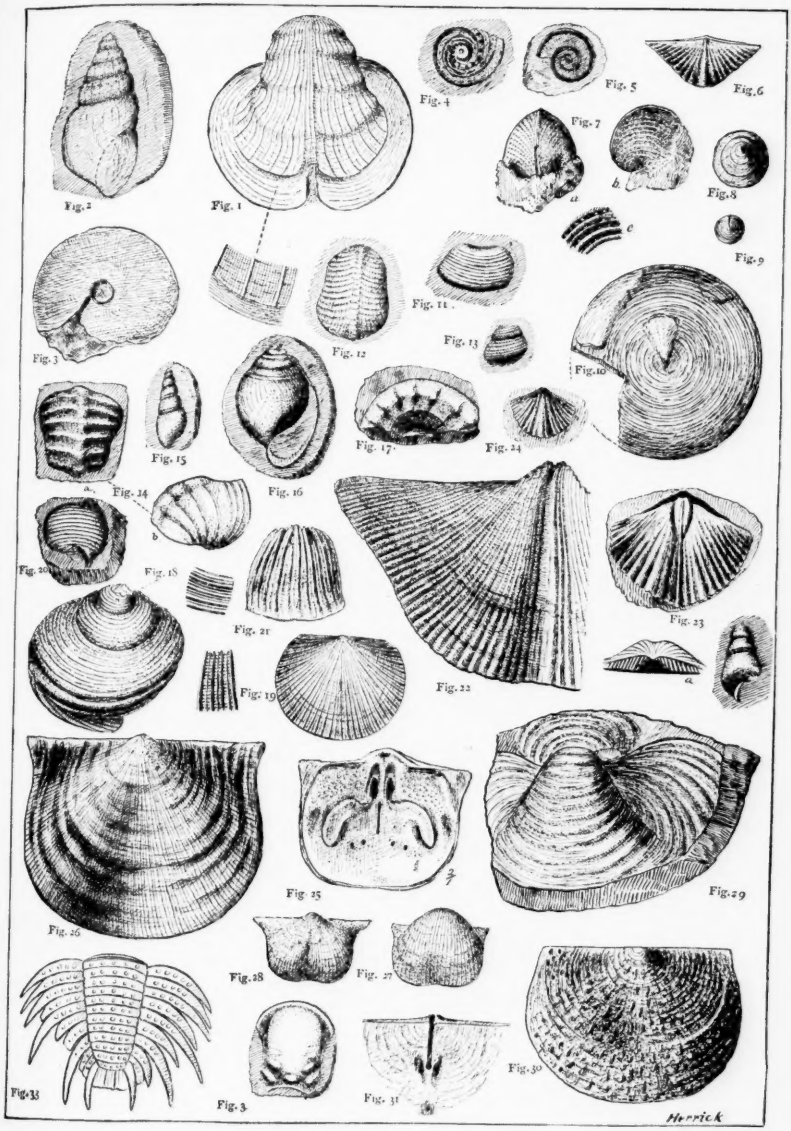
Fig. 23a
HEPPLER

PLATE I.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Herrick

PLATE II.

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Fig.3

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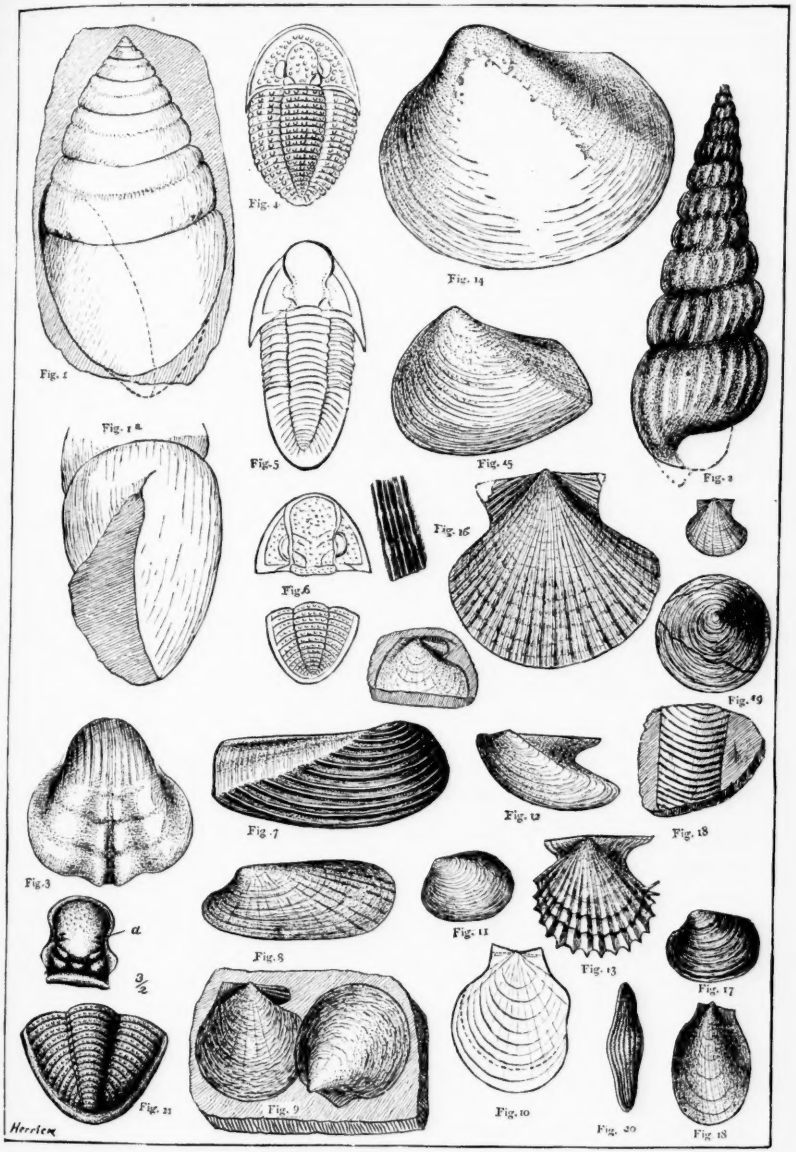
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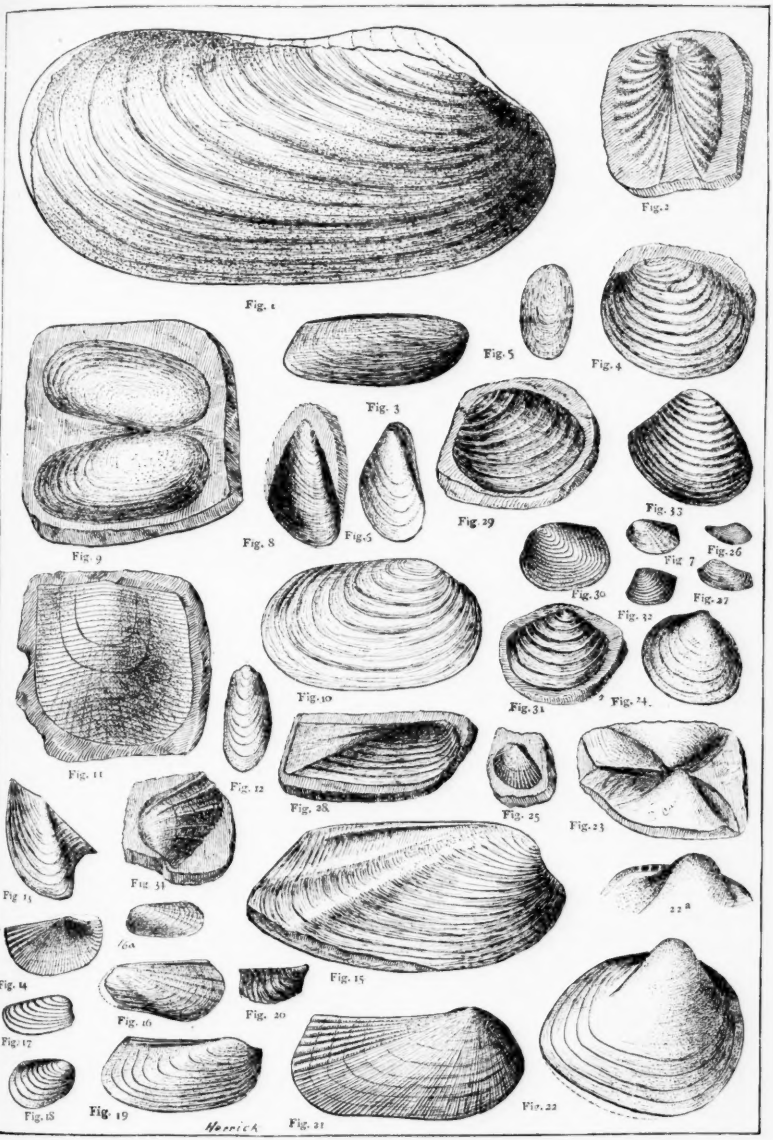
PLATE III.

Fig. 13

Fig. 14

Fig. 17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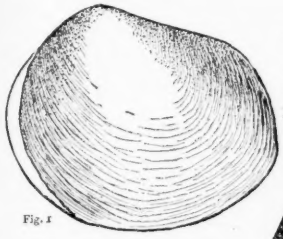
Horrick

PLATE IV.



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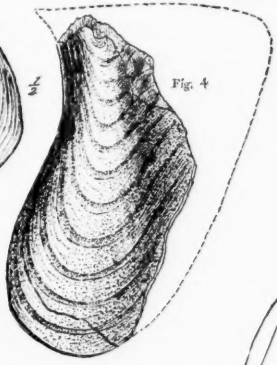

½ Fig. 4

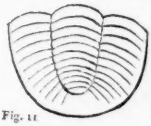

Fig. 11

Fig. 2

Fig. 3

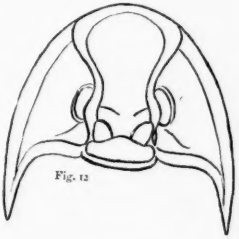

Fig. 12

Fig. 8A

Fig. 5.

Fig. 13

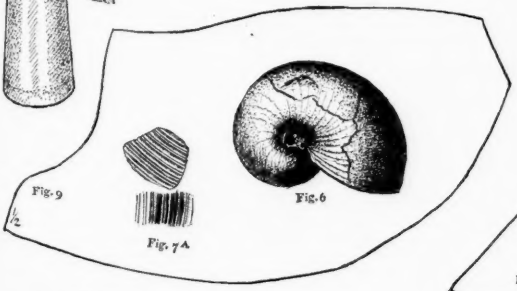

Fig. 9

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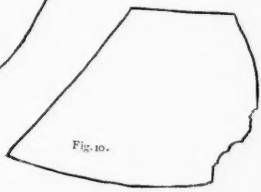
Fig. 7A

Fig. 6



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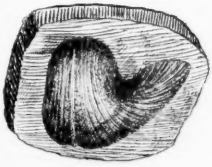


Herrick Fig. 7

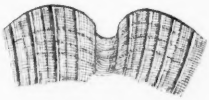
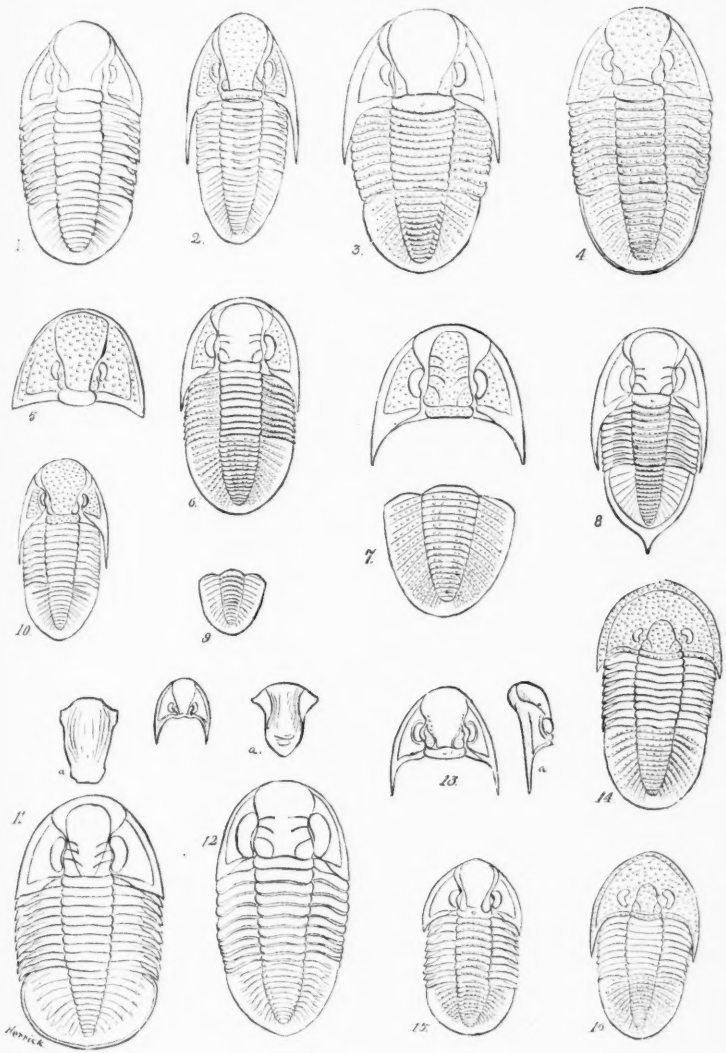


Fig. 8A

Fig. 8

PLATE V.



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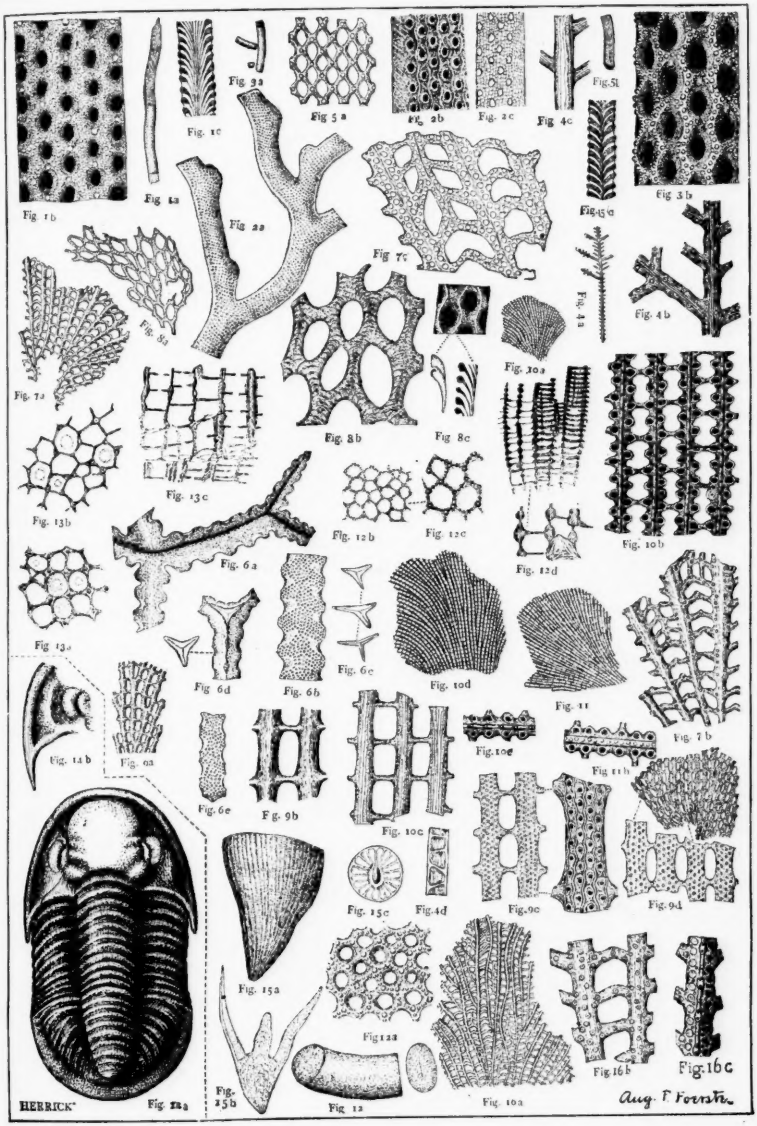
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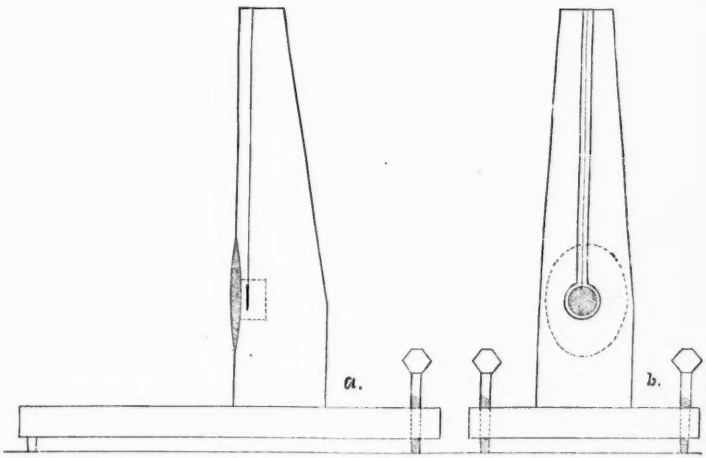
PLATE VII.



MAGNETOMETER.

PLATE IX.

BULLETIN

OF THE

SCIENTIFIC LABORATORIES

OF

DENISON UNIVERSITY,

EDITED BY

C. L. HERRICK, Dep't. of Geol. and Nat. History,

AND

A. D. COLE, Dep't. of Chemistry and Physics.

VOL. II, PART 2.

GRANVILLE, OHIO, APRIL, 1887.

V.

GEOLOGY AND LITHOLOGY OF MICHIPICOTEN BAY.

RESULTS OF THE SUMMER LABORATORY SESSION OF 1886.

C. L. Herrick, W. G. Tight, and H. L. Jones.

[*Read before the Denison Scientific Association, April* 23, 1886.]

The excursion was undertaken with a view primarily to the enlargement of the working series of crystalline rocks in our cabinet and in the hope of affording a useful supplement to the class-work in lithology, though it fell to the lot of but few of the class to participate in it. It is hoped that these peripatetic summer training classes may become a valuable adjunct to the regular work so long, at least, as we have, as now, numbers who expect to work as scientific specialists.

The party left the Sault Ste. Marie, on the little steamer Remora, and arrived at the fishing station near the mouth of the Dog River, in Michipicoten Bay, at 4 o'clock in the afternoon when, by the kindness of the agent, we were promptly transported to our permanent camping station on the left bank of the Dog River at its mouth. Here a temporary laboratory was located, and by means of oars and sail much of the adjacent coast was carefully studied.

Those not particularly familiar with recent geological literature may ask why this special locality was chosen for the summer's work and what is the nature of the problems whose solution was sought. To properly answer these questions would be to review in great part the writings of most of our leading geologists during a period of many years, especially those of Canada, Michigan and Wisconsin. Such an extended review is, however, rendered unnecessary by the fact that

several of the recent writers on the geology of Lake Superior have given such collations and discussions from their several points of view, notably Wadsworth, in "The Azoic System and its subdivisions", 1884, and Irving, in his "Copper-bearing rocks of L. Superior", 1885. Recent discussions may also be found in the Annual Reports of Minnesota. In the region in question the geological relations appear to be relatively simple, but at the same time so intimately associated with the more intricate regions now chiefly under discussion as to make any conclusions which can be reached of considerable value.

In general then, the region northward from L. Superior is a part of the great V-shaped area of crystalline rocks classed as Azoic and usually grouped in two great series, the one largely composed of gneisses and granites and called Lawrentian, and the other, assumed to be higher (and hence later) composed of crystalline slates and schists. This whole series is supposed to consist of altered sediments, but with an unconformity between the two groups. The evidences of life are restricted to those furnished by the exceedingly problematical Eozoon and the presence of graphite and iron. The original name given to both these members was the term Azoic, applied by Foster and Whitney, in 1850. Whitney and Wadsworth vigorously assert that there exists no reason for changing this name (as to Archean) or subdividing the series (into Lawrentian and Huronian). The Canadian geologists claim that the Huronian schists are constantly unconformable to the underlying Lawrentian and frequently contain pebbles from it. To this Wadsworth and Whitney reply that there is a lack of observation to substantiate the claim of unconformability and that the pebbles are high in the series of the Huronian and not in any sense basement conglomerates. At page 557 of the "Azoic System," these authors seem to imply that the Huronian conglomerates are formed by the imbedding of matter ejected in a fragmental state in a detrital magma.

In the region under consideration a further difference of opinion seems to prevail. Irving, in the map of L. Superior, given in his valuable report on the "Copper-bearing Rocks," marks all the granitic areas as Lawrentian and the schists as Huronian, while the Canadian geological map indicates all the granite areas near the lake and associated with the schists as eruptive, although a region to the north is covered with the Lawrentian. In the sequel the evidence which leads us to accept the conclusions of the Canadian geologists as to this particular region, is reviewed in detail so far as our material warrants.

The most detailed account of the relations between the schists and granite seems to be that of McFarlane, who says: "The manner in which these Huronian rocks adjoin those of the Lawrentian series may be observed on the north shore between Michipicoten Harbor and Island. I paid some attention to that point of junction which lies to the west of Eagle R., the precipitous cliffs to the east of which consist principally of diabase schist and greenstone slate. A few miles to the west of these cliffs and at a point bearing N. 29°, 5° E., from the east end of Michipicoten Island, the Lawrentian granite is penetrated by enormous dykes of dense basaltic greenstone (having the peculiar doleritic glitter when fractured) which contain masses of granite. This greenstone is also seen in large masses, which can scarcely be called dykes, overlying the granite and enclosing huge masses of that rock, one of which I observed to be cut by a small vein of the greenstone. From this point to the Eagle R. these two rocks alternately occupy the space along the shore, seldom in such a manner as to show any regular superposition of the greenstone on the granite, but almost always more or less in contact with each other. The greenstone however, becomes more frequent towards the east and at Eagle R. it has almost replaced the granite, and assumed a lighter color, and an irregularly schistose structure. The strike of these schists is at places quite inconstant; they wind in all directions, and what appear at first sight to be quartz veins accompany their contortions. On closer inspection, however, of the largest of these, they are seen to be of granite, but whether twisted fragments of that rock or really veins in it, is at first glance very uncertain. * * * Although they are seldom or never angular they can scarcely be regarded otherwise than as fragments whose shape has been modified by contact with the greenstone. * * * Either the granite forms veins, penetrating the schistose greenstones, in which case the latter are the older rocks; or it is in the form of contorted fragments, in which case the enclosing rock may be of eruptive origin. The latter supposition seems to be most in harmony with the facts stated." (Rep. Progress 1863–66.) Commenting on this account Whitney and Wadsworth remarked: "It seems almost incredible that a geologist, who professed to be a lithologist, should have been unable to ascertain the relations and relative age of these rocks when so many excellent exposures were observed, as he states. His observations show clearly that both formations here are eruptive and of the same geological age." (Azoic System, p. 346.)

In the light of the facts presented beyond it seems that the danger is sufficiently obvious in attempting to generalize on the basis of observations covering a portion of a district and still farther of dogmatizing on the basis of such a description as the above. In the first place our study makes it appear that McFarlane, in his hasty examination, failed to distinguish between the dykes and bosses of eruptive diabase, which break through the granite as well as the schist, and the metamorphosed schist itself. Having made this strange error, consistency required that the obviously stratified schists should be also included, so it became easy to consider the trap as a phase of the schist, all being necessarily eruptive. Had he gone five miles farther east he would have encountered schist conglomerates with water-worn bowlders of gneiss, etc., and would have found it necessary to include them also in the the curious group of igneous rocks which he calls greenstones. The confusion above referred to is the more strange because at this point there is actually no difficulty in distinguishing the eruptive granite from the eruptive trap and the metamorphic schist. At other places all the explorer's acumen and care is taxed to distinguish the schists from the dyke-matter, there having been extensive interaction between them. It would seem that from the above statements it should be obvious that a careful and detailed study of even a limited area might serve a better purpose than a cursory examination of a large field. With this in mind the short time at our disposal was employed in carefully working out the details of the geological structure of a small area about Michipicoten bay where, fortunately, a very considerable variety of rock may be encountered within easy distance. Judging from the brief accounts of this region published, we expected here to find the three formations in doubt in close juxtaposition. Pitching camp at Dog river, the coast was explored foot by foot in each direction as time permitted, while excursions into the interior enabled us to observe the substantial uniformity of strike and texture for several miles inland. We proposed to ourselves the following questions: (1) What distinct formations may be recognized, both lithologically and stratigraphically? (2) What is the relative position and age of each? (3) What has been the source of the material and what the circumstances of deposition? (4) What alterations in composition and position during the subsequent changes? (5) How may the present topographical features be explained?

It soon became evident that we had to deal with three easily rec-

ognizable and distinct classes of rock which, in this region at least, show no sign of interblending. The first, consisting of slaty rock, inclined at a high but varying angle and reposing upon an evidently igneous mass of granite which frequently projects through the slates where denudation has removed them. The third series occurring only as a thin belt for a short distance near cape Cargantua, consists of conglomerate and sandstone which laps unconformably upon the slates and is largely re-enforced by igneous overflows and intrusive masses and forms the entire island of Michipicoten.

We first directed our attention to the series of slates which varies sufficiently lithologically to afford much field for conjecture. First, does the cleavage really indicate sedimentation, or is it the result of metamorphic action on an igneous rock? We were fortunate in lighting upon the spot of all others most decisive on this point. It was easy to convince ourselves that the cleavage followed closely the sedimentation planes, for the lithological character of adjacent bands is sufficiently distinct to prevent mistake. The occurrence at more or less regular intervals of beds of conglomerate altered to schist-conglomerate, was especially decisive. These broad bands containing large boulders as well as pebbles of granite and felsite-porphyry, preserving their water-worn outlines and even jointage planes extend for miles along the line of strike. The only stratified granitic rocks seen were calcareous gneisses interlaminated with the schists near what is assumed as the core of a great fold and thus representing possibly the extreme of metamorphism.

Before proceeding to a discussion of the individual exposures the first may be analyzed as follows: I. Greenish, more or less unctuous slate varying to mica schist or hornblendic schist, always with more or less calcite and chlorite. Although adhering to one facies it is greatly influenced by the three classes of intrusives with which it is in various places interbedded.

1. The most distinct of these groups of intrusives is made up of diabases and diabase porphyrites which perforate the granite and intersect the schists in the planes of strike and dip. No difficulty ever exists in determining the contacts of these dykes. The aphanitic margins nearly always present sharp lines of contact. In some cases (as No. 1108) the dyke-rock embraces fragments of granite and wraps itself about the altered fragments.

2. Rocks having the composition of mica-diorite or diorite, but containing much calcite. Rocks of this group tend to assimilate closely in appearance and structure to the schists in contact and suggest the possibility of their having been the products of metamorphism of the schists themselves again altered by slow metasomatic changes. A circumstance greatly favoring this theory is the fact that the dykes in the underlying granite are always diabases so far as observed while the diorites are very frequent in the schists. That the contact action of the granites was amply sufficient to produce such fusion is abundantly demonstrable.

4. Orthoclase and quartz-orthoclase felsite-porphyries occurring under two conditions, but generally in such a way as to suggest an extraneous origin of the porphyritic ingredients; first, contacts of conglomerates with dykes of diabase or of diorite, second, interbedded layers in the schist with adjacent alteration and veiny structure. We incline to the belief that the greater part of the porphyry can be traced directly to metamorphism in such conglomerates induced by adjacent later eruptives.

Having thus briefly disposed of the two older groups we will now consider the relation of the third or Keweenawan series to these. The direction of the strike and dip of these series on Michipicoten Island and Capes Choyye and Cargantua, furnish the only data on which to base our conclusions. The strike on Michipicoten Island appears to be in general a little N. of E., varying from the E. end of the island to the W. end, toward the west end becoming more northerly. At cape Choyye the strike seems to be in a direction a little W. of S., while at cape Cargantua it extends in almost a southern direction, varying a little to E. This would seem to indicate that the older rocks upon which the Keweenawan rests formed a synclinal with its axis in a N. E. direction. The position of the granite rocks on either side of this axis would indicate a synclinal rather than an eroded anticlinal, as is the general rule. Also the fact that the Keweenawan is deposited within the basin itself and its margins abutt against the high cliffs of the eroded older rocks. The relation of the basement conglomerates exposed at cape Choyye to the older series will be discussed upon a later page. The most complete discussion of the Keweenawan is that of Prof. Irving, in his monograph of the Copper-bearing Rocks of Lake Superior. We may now proceed at once to a

Description of the Rocks of Michipicoten Bay.

It has been thought best to present these descriptions in about the order in which they were examined by us, in order to place the reader as nearly as possible at the same standpoint in regard to the questions under discussion.

At the mouth of Dog river and extending along the coast for some miles is No. 1001. *Typical chloritic slate*, strike S. 32° E., dip 80° N. E. Very fissile and somewhat unctuous. Under the microscope, the magma is close-grained, with much chlorite, irregular scales of biotite, large irregular grains of calcite, occasional fragments of orthoclase, fewer quartz grains, numerous crystalline grains of magnetite, and some irridescent white scales which may be talc. The calcite, which is characteristic of most of these schists, is here frequently granularly decomposed in the centre of the grain. It is easily recognized even in small grains by its irridescence and in larger ones by the rhombohedral cleavage and twins.

Nos. 1005–1007. Same slate as No. 1001, but modified by contact with dyke of No. 1004. The surfaces of the lamellæ are covered with wavy ridges arranged in "cohesion figures." The dark ingredients are collected in zones of varying width. Grains of orthoclase and plagioclase occur as well as quartz, which last in some cases is surrounded by a zone of radially arranged fibres or plates of chlorite. The calcite is also collected into zones. In one place (No. 1007) in proximity to a quartz vein the rock is largely made up of rather regular though decomposing feldspar, chiefly orthoclase in Carlsbad twins. The contact with the quartz is sharp, but the latter is permeated at the edges by calcite and into it are fused iron globules from the schist. Both these circumstances give evidence of high temperature during the formation of the vein.

At the point one half mile east of Dog river is a wide band of conglomerate (No. 1023 see beyond) passing which, we encounter broad bands of yellowish felsite-porphyry and obliquely arranged lenticular masses and strings of a similar character (Fig. 5, Plate XI.)

No. 1008 is a specimen from the lenticular masses and consists of an exceedingly fine-grained felsitic magma, containing large rounded grains or nearly perfect crystals of quartz and feldspar, (Plate XI, Fig. 2.) The grains of quartz, though greatly rounded, appear to have been doubly terminated crystals, while the feldspar, which is nearly all or-

thoclase in Carlsbad twins, is more frequently fractured than rounded and is often filled with tongues of interpenetrating magma. This magma is beautifully fluidal, the dark ingredients (biotite, chiefly altered to chlorite) are scattered in crevices of the feldspars or sheltered spots behind them where they have drifted like float-wood.

No. 1009, from the bands, is essentially similar, but is much finer-grained and has fewer and smaller porphyritic ingredients. There are mica rosettes and groups of magnetite, pyrite, apatite and other accessories, as well as veins of calcite.

No. 1011. Chloritic schist one-half to three-fourths of a mile N. E. of Dog river. It is greatly contorted, unctuous, containing large quantities of calcite in the form of veins which conform to the contortion. Microscopically it appears to be composed of a ground mass of chlorite scales which when reduced to very thin sections lose their polarization colors and pleochroism. This ground mass is filled with large crystals of much altered orthoclase, which have a tendency to aggregate at 90° to axis c. The titanic iron shows all the gradations to titanite. Large calcite grains showing characteristic cleavage in three directions, with banded structure. The crystals of apatite penetrate all the ingredients of the rock. The rock appears to be much altered from the influence of the interpenetrating diabase dykes. Here as in other places it seems as if the interpenetrating dykes coming through the primitive schists had fused the lower portions which oozed up along the sides of the dyke and in cooling formed the more coarsely crystalline rock No. 1012. (Plate XII, Figs. 1, 2, and 3.)

No. 1012. Dark gray, coarse grained, unevenly fracturing rock, intersected in all directions by veins of various minerals. Microscopically it appears coarsely crystalline, with orthoclase and plagioclase magma. The rock contains a considerable amount of biotite, some calcite and a very few grains of hematite, with crystals of apatite scattered through it sparingly. It appears as if this rock was the slowly cooled product of the fused lower portion of the schists in which mica and plagioclase have crystalized out. This all, apparently, through the influence of the dyke which comes up through this boss and forms No. 1013.

No. 1013. A fine grained dark rock presenting all the characters of a typical diabase. The line of contact with No. 12 is very sharply marked.

Next, passing up Dog river about one-eighth of a mile from its mouth, we encountered a large dyke 15–20 feet in width, No. 1017, which in microscopic section presents all the characters of a typical diabase similar to the other dark, fine-grained dykes. Its feldspars consist of oligoclase with an angle of about 26° and labradorite with an angle of about 48°. Some magnetite, otherwise very free from accessory ingredients. Adjacent to this dyke is the indurated slate forming No. 1018, finely crystalline, containing large quantities of brown mica in scales in O plane, also many irregular grains (Plate XII, Fig. 5A), and grains of magnetite broken up into fine powder, also a few calcite grains, showing characteristic cleavage. The mica appears to be decomposing to chlorite, forming a chlorite and quartz basis. Pseudomorph crystals of chlorite after mica are seen (Plate XII, Fig. 5B.) Passing farther up the river the slate becomes porpyritic for a considerable thickness.

No. 1019 is a sample of this porphyry. It has a very fine quartz magma, with brown mica. The orthoclase crystals have more or less regular crystalline outlines and its general appearance is strikingly similar to that of the pebbles in the conglomerate No. 1023. In close contact with this porphyry is No. 1019a, a dark very fine grained typical diabase. Its relation to No. 1019 is shown in Plate XI, Fig. 6. It appears from the relations as if the porphyry (No. 1019) was once continuous with the conglomerate No. 1023, which is found a little farther up the river, but has lost its conglomeritic structure and suffered the complete fusion of the pebbles and schist through the influence of this dyke No 1019a.

No. 1023 is the band of conglomerate at lower Denison Falls, where it is from 39–75 feet in width. Its ground mass, which is nearly similar to the adjacent schist, is filled with water-worn pebbles of a porphyritic rock No. 1023a. (See Plate XII, Fig. 9.)

No. 1023a. These pebbles have a sharp outline and can be perfectly separated from the ground mass. They show unmistakable evidence of the action of water in rounding their corners and angles before their deposition. They also show the jointage planes of the primitive rocks from which they were derived. Their general external appearance is about the same, but under microscopic examination of a large number of slides it is clearly shown that they consist of two distinct rock species. This distinction is well marked, for there is shown no gradation from one to the other, even in pebbles which are only an

inch or two apart and which must have been subjected to the same agencies of metamorphism. One of these species presents all the characters of a typical granite with much quartz and orthoclase and few accessories. There is some pyrite, probably secondary. The orthoclase is much altered and gives aggregate polarization. The quartz grains are filled with numerous fracture lines and are rendered almost cloudy with microlitic inclusions, both apparently the result of intense heat and pressure. The other variety is unmistakably porphyry, with an almost irresolvable ground mass of quartz filled with large crystals of orthoclase, with now and then a large grain of quartz. These pebbles also appear to be very much altered from the action of heat. The orthoclase still can be determined by its aggregate polarization, crystalline outline and perpendicular extinction. In microscopic characters this rocks resembles very closely the porphyritic phase of the schist further down the river. A mile or so above the falls is a shining, fissile chloritic schist (No. 1027) which under the microscope proves to have a very uniform ground-mass of quartz and chlorite with a very little brown mica and numerous and regularly distributed minute unterminated crystals of an orthorhombic mineral with optical characters of staurolite. Much of the schist is of a highly metamorphic character, but preserves the usual strike and dip.

Nos. 1016, 1029, 1031, and 1036 are various phases of gneiss extending from a point one-half a mile east of the union of Mountain river with Dog river, in the line of strike, to intersect the coast several miles northeast of the mouth of the latter. This series consists of several bands of varying width and texture interstratified and conformable with the schists. No. 1016 occurs along the shore near the Terraces, forming high bluffs. It is a very fine-grained dark gneiss, with obvious bands of flesh-colored feldspar. Microscopically the mass of the rock is composed of much green muscovite mica, considerable epidote in zones (recognized by its bright yellow color,) relatively large amounts of oligoclase and decomposing feldspathic ingredient (orthoclase). There are innumerable needles of a transparent substance apparently derived from the mica. Some calcite is probably derived from the same source. Very little quartz is present.

No. 1036 is identical with No. 1016 and is from an adjacent exposure, but it is nearly schistose and the section exhibits a few veins

of amorphous substance full of minute needles (sillimanite ?) like those above mentioned.

No. 1031 is the same gneiss where it intersects Mountain river. Here it is somewhat coarsely granular, containing more orthoclase and biotite mica. There is some (perhaps secondary) quartz in the confused portion. The transition to the schist is here very readily seen, there being no unconformity.

No. 1029 is a phase of No. 1031, just at contact with the schist and partakes of its characters. It has biotite in large quantities in conspicuous masses surrounded by irregularly disposed augite grains. The most of the remainder being plagioclase and orthoclase, with some quartz and an occasional large grain of calcite. The augite is very brilliantly polarized, but chiefly in grains or much broken crystals.

From the above it may be gathered that these gneissic rocks form really an integral part of the schists, being more highly metamorphosed than they. We incline to regard them as the axial part of the fold, the strata repeating to all appearances on either side, as indicated in our diagram. The relation of the strata is such as to permit us to consider the schist conglomerate a true basement conglomerate.

Passing beyond the gneiss the same series seems to be repeated in reverse order, though more careful examination is needed on this point

No. 1037 resembles closely 1009 and is followed by No. 1038, which is identified with the conglomerate No. 1023. This is followed by schists. The contact of these schists with the granite is very suggestive. At a little distance from the contact, the schist (No. 1045) is a shining green chloritic mica schist, with light specks scattered through it. Under the microscope it is seen that the green mineral is arranged in wavy bands separating aggregates of quartz in a finely granular condition with large porphyritic brown grains, seemingly aggregates. Close examination shows however that the brown granular appearance masks calcite, with its cleavage and irridescence, and a comparison with the part more nearly adjacent to the granite shows the brown grains to have been feldspar from the latter.

No. 1046 is on the granite side of the contact and is an altered granite, having the quartz and feldspar imbedded porphyritically in a magma like that of the schist. The orthoclase is much altered by heat and the crystals are margined by calcite. The quartz is less fractured than in 1045, but on the whole the two are much alike. The original

crystals of biotite (?) are broken up and greatly altered. The unaltered granite (No. 1042) is very coarsely granular and is perforated by many diabase dykes having the same general strike as in the schist. The granite continues to Little Bear river and thence to Dore′ river, to the east of which a chloritic slate appears. The strike is S. 50° E. with a dip toward the southwest of about 45°, though the strata are very tortuous and embrace included masses. The contact with the granite is here as elsewhere evidence of the eruptive nature of the granite. Irving's map does not correctly represent the distribution of the granite in this bay. Gros Cap is the promontory west of Michipicoten harbor and is said to bear hematite veins. Bell says it is composed of slaty diorite, though the only rock seen by us was a tough silicious chlorite schist. At Michipicoten river the rocks are said to be dark hornblendic mica schist.

Leaving Gros Cap we crossed the entrance to Michipicoten harbor and encamped upon a narrow beach nearly directly south of the point. The rock here is strongly tortuous and confused. Much of the rock is porphyritic in a grayish-green base, while other portions are of dense close texture and uniformly micro-crystalline. In one place beneath the water the porphyritic rock could be seen to contain large rounded masses of a different color, often a foot or more in diameter. These were supposed to be similar to the conglomerate pebbles of the west side. As typical of much of the unporphyritic rock of this shore we select No. 1068, which appears to the eye like a moderately fine-grained diorite. The thin section shows it to have undergone great alteration. The greater part of the field is made up of elongated unterminated fibrous crystals, lying at all angles and frayed out at the ends. These are of a pale green color and scarcely pleochroic. The polarization colors are very brilliant, like those of tremolite. In cross section two sets of cleavage lines, with an apparent angle of 120-130° appear, while the longitudinal cleavage lines are frequently wavy. The twins are numerous and in the plane i-i, and the extinction angle $c : c$ = nearly exactly 15°. This combination of characters is hard to understand. The absence of pleochroism and brilliant polarization indicate a monoclinic augite, but the extinction angle, cleavage, and habit are like hornblende. This is, therefore, a decomposing hornblende like uralite in general appearance and like actinolite in characters. The iron has nearly disappeared from the whole rock, a few scales of hematite being found in the hornblende.

The remaining ingredients of the diorite, with the exception of the rather small amount of quartz, are more completely altered. The place of the plagioclase is taken by an opaque white amorphous substance and the interstices are filled with granular light material. A few crystals of decayed augite are seen, which have large quantities of iron in scales and grains. Here and there grains of calcite indicate where some of the decomposition products have gone. There are exposed a few interesting masses of ilmenite, in which the hexagonal plates are matted obliquely, which show under the microscope the characteristic bronzy reflection.

No. 1064 is essentially similar. It is a very tough, homogeneous, greenish-grey rock. The actinolite is in the condition described above and the accessories are ilmenite, calcite, and apatite. It presents to the eye the appearance of a fine-grained diorite, altering to serpentine. Irregular bands of a lighter colored rock occur in this mass. Such a specimen is No. 1065, which is a confused mass of finely granular material in which quartz, calcite and chlorite can be identified. Strings or veins of calcite are abundant, and scattered through the magma are many dark grains, the centres of which are generally filled by a single crystal of secondary calcite.

No. 1066. This is the porphyritic phase before spoken of, which also contains the larger pebbles. Here and there in the section are large rounded grains of quartz, broken and intersected by the finely granular magma. The latter is not essentially different from the basis of 1065, but is crowded with rounded grains of oligoclase. Grains of secondary calcite and veins of the same, also pyrite and perhaps titanite are seen in the slide. It would appear that the magma is full of minute scales of chlorite. (Plate X, Fig. 2.)

The only explanation suggested for the curious condition of the rock here is that the metamorphism was excessive and resulted in a thorough suffusion of the original slate with intrusive matter as well as pasty portions of the adjacent sediments, reducing all to a somewhat homogeneous character. The conglomeritic phases of the slate being rendered pasty, the pebbles were at first unaffected and were intruded upon by the more fluid matter below. They were subjected to more violent flowage by reason of the obstinate pebbles during which the ingredients of the pebbles were partly set free and, although the magma was in part melted, the larger crystals remained dispersed in

the magma in the corroded condition already described. The calcite and chlorite date from later periods.

At this point are a number of trap dykes, but the extreme point (Burnt Point?) is made up of granite, which continues to the mouth of Riviere de la Vieille. Just southwest of the river are precipitous cliffs, 600-800 feet high, made up of the highly metamorphic equivalent of the schist. Here at places the granite appears beneath the slate, which is unconformable and tortuous, without obvious stratification. The granite rises only a few feet above the water's edge in undulations and seems to have thoroughly fused the superincumbent schist at contact. A few miles further south, toward cape Choyye, the high bluffs recede from the shore, leaving the point composed of Keweenaw conglomerate and sandstone, which laps out near the water's edge at a slight inclination.

No. 1074 is a specimen of the schist taken near the underlying granite and is a greenish, irregularly fissile rock, completely checked up by joints and so altered and veiny as to act as an aggregate with much chlorite.

No. 1075, taken near cape Choyye, is an irregularly lamellated mica schist. The section shows much brown mica and quartz, some apatite, magnetite, pyrite, and scattered porphyritic more or less quadrangular grains appearing like completely decomposed feldspar. Although dip and strike, as taken, were dip 60°, strike S. 10° W., we rather incline to believe that this is the same rock as that on the west side of the bay, with a strike which might bring it hither.

Returning to Dog river, we proceeded westward for about six miles to near Eagle river, a small trout brook near the western limit of the bay. Here are precipitous cliffs nearly 800 feet high. The rock here consists of much altered highly crystalline schists, varying from green to brown (No. 1049-1049a). The mica is largely altered to chlorite in the green, while it is reduced to a powder in the brown and mixed with hematite. Both contain very large quantities of calcite, as a product of alteration of mica no doubt. These rocks contain much quartz. The strike is E.S.E., *i. e.* much more nearly east than farther northeast, and the dip only about 45°. Here in many places diorite lies interbedded between the strata of schist. This diorite is composed of the same twinned hornblende, mentioned at the east side of the harbor, but although it is superficially identical it differs in retaining strong pleochroism. The extinction angle and general appear-

ance of the section, otherwise is identical. Here, too, the adjacent schist has assimilated itself to it most remarkably in general appearance, though a glance at a section shows it to be of a quite distinct character. It is really an *altered mica schist* (!) consisting of quartz, chlorite, much calcite and iron salts. This fact that certain eruptives have the power to assimilate the adjacent rocks so closely in external appearance as to defy recognition, while not altering the real nature of the rock, needs to be constantly borne in mind by field-geologists. These rocks, classed as greenstone slates and considered as eruptive by previous writers, can with care be readily separated into interbedded sedimentaries and eruptives. A succession of such dykes is seen east of Eagle river. West of Eagle river, especially on the jutting point referred to by McFarlane, the schist suffers the extreme of metamorphism, being twisted and gnarled in every conceivable way, at the same time seggregating various minerals in pockets and lenticular masses. Veins of granite perforate the schist and include it in irregular masses. The effect of such intrusive action is here well seen. The fragments of schist so inclosed are angular and though often fused into the granite, never permit comparison with the Dog river conglomerate. A direct comparison of this sort may bring out relations hard to verbally explain. The contact samples show much epidote which forms zones at the contact, veins in the schist, or replaces the hornblende in the granite. At this point is this immense dyke No. 1056.

No. 1058 is schist at the contact and consists almost entirely of epidote containing strings and fragments of the aphanitic margin of 1056. Westward the granite constantly encroaches on the schist, which is here a typical mica schist of fine texture.

The diabases, as before stated, are exceedingly monotonous in composition and structure. A considerable range of variation in the relative size of the ingredients is the chief divergence. They never carry an appreciable amount of olivine and the feldspars are either labradorite or labradorite and oligoclase, the former with brilliant polarization colors and distinct outlines.

No. 1056 may be taken as a type of the whole series. This is especially interesting as being the dyke northeast of Michipicoten island, called, by McFarlane, doleryte and considered by him and by Wadsworth after him, as one of the sources of the schist. This is

perhaps the largest dyke encountered, being over 75 feet wide. Its contact can be traced with both granite and schist. The former is more or less enclosed by branches from the dyke, while the latter is, in the main, sharply distinct. Yet in places there is some excuse for the confusion of the two. The schist is very tortuous and variable and in places is dark, closely granular and might casually be mistaken for the diabase. The epidotic character of the schist as well as the aphanitic marginal zone of the diabase prevent real obscurity, however.

This diabase is rather coarsely granular and dark in color. The microscopic structure is beautifully distinct. Very large elongate prisms of brilliantly polarizing labradorite and fresh, pinkish-brown augite, the latter perforated in all directions by the former, make up the most of each field, though some of the augite is altered to viridite and epidote (?). The magnetite, of which there is considerable, is altered to hematite and limonite. Very little apatite is present. (See Plate XII, Fig. 4.)

No. 1111, from the dyke at the mouth of Dog river, is typical of another phase of these dykes. While most of the feldspar gives angles indicating labradorite, the paler crystals generally fall below 36°, indicating, according to Pumpelly's method, oligoclase. The augite is in long twinned crystals, which are often bent or frayed out at the ends. The margin is often greatly altered, (Plate XII, Fig. 8,) products of alteration being uralite in strongly pleochroic fibrous masses suffused with brown, and large flakes of hematite. The numerous large grains of magnetite or titanic magnetite altering to titanite, may be regarded as autochtones. The augites show very fine interrupted fibrous structures, || O, the angle c : c being about 39°.

No. 1004 is a finer-grained diabase, east of Dog river, containing much metallic oxide and numerous greenish grains, with aggregate polarization and tendency to be surrounded by iron grains. A very few crystals of orthoclase, with zonary structure (Plate XI, Fig. 4,) are also noticed.

No. 1019a is a peculiar modification, being a densely black diabase-porphyrite with ilmenite instead of magnetite, The magma can be resolved by a high power to an irregularly granular mass, which is filled with peculiar grouped rods of the titanic iron. (Plate XIII,

Fig. 6.) The porphyritic grains are of plagioclase with scattered augite. It is thought that much of the granular magma is augitic. The ilmenite is altered in many places to titanic iron.

In discussing the Keweenaw rocks as exposed on Michipicoten island, cape Choyye and cape Cargantua, we shall describe only enough to give a clear idea of the relations of this series to the older Lawrentian and Huronian, as found in this region. We may consider these rocks under two heads; first, the eruptive igneous, including all the diabases, amygdaloids, pseud-amygdaloids and perhaps the porphyries; second, the sedimentary and metamorphic. The former might be considered the result of a single series of overflows closely related. The cooling of these, taking place under different conditions, as in the presence of water, superheated steam, under great pressure or otherwise, must of necessity produce many different forms of the same overflow. Only those whose structure is in some way characteristic, are here described.

No. 1077 (Plate XIII, Fig. 3.) occurs on the south shore of Michipicoten island, forming the most of the islands along the shore. It is filled with vein matter, principally of quartz and agate and is also somewhat amygdaloidal. The color is black, with almost a metallic lustre. An uneven fracture and exceedingly tough. The specific gravity is 2.76. Under the microscope the rock is seen to be completely crystalline. Oligoclase makes up a great portion of the section, occurring in long, fine crystals, generally twinned. Rounded grains of augite are scattered irregularly through the mass. Here and there a crystal of orthoclase is present, but much altered. A very peculiar kind of grains, evidently suffused with iron of a bright yellow color, without polarization or pleochroism, filled with inclusions, probably of gas, with concentric lines running through them, is found. There is a very large quantity of magnetite in the rock, not occurring in regular form, but rather filling the interstices between the other minerals. According to Rosenbusch this is a typical diabase.

No. 1082 (Plate X, Fig. 1., and Plate XI, Fig. 3.) is a diabase porphyrite, black in color, with light colored crystals varying from one sixteenth to three-sixteenths of an inch in length, scattered thickly through it. The specific gravity is 2.7. The fracture is distinctly conchoidal. In the aphanitic magma large twins of labradorite cut

the rock in all directions. The following measurements of the feldspar crystals were made:

20°+23°=43° whole angle.
35°+30°=65° " "
25°+23°=48° " "

According to Pumpelly's method this would make the feldspar labradorite. The crystals are exceedingly regular in form, cutting each other in many directions. Inclusions in the crystals are frequent, presumably fragments of the magma. Colors of polarization gray, yellow and blue. Minute crystals of feldspar, all of about the same size, thickly dot the black magma. These are probably of the same kind as the larger crystals.

The next ingredient which attracts attention is the augite. This is not nearly as abundant as the feldspar and does not occur in as large crystals The form of the crystals is rarely regular, generally somewhat rounded. Inclusions of minute needles of apatite are frequent in the augite, also a greenish alteration product, otherwise it is unaltered.

No. 1083 (Plate XIII, Fig. 8.) is a weathered specimen of the same rock. The specific gravity is 2.66, being much lighter than the original rock. Here an excellent opportunity to study the effects of weathering is afforded. The augite has entirely disappeared, not a single crystal in the section possessing any of the augitic characteristics. A greenish product, much colored by the iron of the magma, probably represents the decomposed augite. The feldspar, while in many cases still retaining its crystalline form, is in every case altered, generally from the center. The figure shows one of the less altered crystals beginning to decay in the center. The alteration product is of a light green color, very irregular in form, but in a few cases the regular form of the primitive crystal is retained. The aphanitic magma of the unaltered rock has changed to a yellowish brown, with small crystals of magnetite dotting it all over.

No. 1082a (Plate XIII, Fig. 7.) is the next phase of the diabase. It is a somewhat porphyritic diabase of much lighter color than any of the preceeding, being almost reddish-brown, and showing somewhat the effects of weathering. The specific gravity is less also than any of the preceeding, being only 2.6. The fracture is somewhat conchoidal though not as much so as No. 1082. Under the micro-

scope the effects of decomposition become very manifest. The large crystals of triclinic feldspar have altered to a mineral resembling orthoclase, but very much clouded. The smaller crystals of feldspar have likewise changed, though not as much as the larger ones. The chief peculiarity of the rock is the alteration of the augite into chlorite. These grains are, some of them, an eighth of an inch wide and so can be tested for their solubility in sulphuric acid. These grains are arranged in spherulitic masses, with radiating structure in polyhedra. There is a large amount of hematite and magnetite present in the section.

No. 1085 is banded sandstone, with alternate layers of brown and gray color. The grains are exceedingly minute, situated in a highly argillaceous magma. They are so small that they are very difficult to make out, but some of them are evidently triclinic feldspar from their form and angle of extinction.

No. 1088 (Plate XII, Fig 7.) is a very black rock, with none of its ingredients macroscopically visible. It has a shelly fracture and is quite brittle. Under the microscope it is seen to have a crystalline base of minute needles of plagioclase, in many cases twinned, with small grains of augite frequently surrounding them in sort of a pseudo-amydaloidal arrangement. Dotting the section are regular crystals, probably magnetite. Here and there are found large crystals of plagioclase, with regular form and entirely unaltered. This rock is a typical diabase aphanite. It is situated on the southwest corner of the island, overlying a bed of conglomerate, which will be described later.

No. 1091 (Plate XII, Fig. 4.) is a specimen taken from the zone in contact with the conglomerate. It is dark in color, minutely crystalline and crossed in all directions by minute veins. Its specific gravity is 2.79. Small crystals of plagioclase are very abundant, also iron grains. The vein matter has aggregate polarization. Whatever augite is present it is entirely broken up, but still retaining its bright colors of polarization and angle of extinction. The amygdules here are small, generally greenish in color, without polarization or pleochroism. Alteration product much resembling olivine is present in large quantities. This rock is very similar to the one figured by Irving, on Plate IX, in his "Copper-bearing Rocks of Lake Superior."

The amygdaloids on the northwest corner island have not yet been carefully worked up by us. They are highly amygdaloidal containing large masses of calcite. Plagioclase, together with large

grains of augite much broken up, always makes up a considerable per cent. of the rocks. They also carry quite a large amount of suffused iron.

On the southwest corner of the island, rising above the water's edge several feet, occurs a fine-grained conglomerate with small, sharply angular grains. Embedded in this are large boulders from one to twelve inches in size, of several different kinds. The question of the origin of these boulders becomes of the greatest value in establishing the relations of the different series. One of the most numerous is a granite, quite close-grained, light colored, containing somewhat altered white mica, orthoclase much changed, but still retaining its form, and quartz. There are no accessories present. These boulders have all been rounded by the action of water.

No. 1087 (Plate XIII, Fig. 2.) is from a typical mica schist of a light gray color, dotted all over by minute black crystals, giving it somewhat of a salt and pepper color. Microscopically the rock is seen to have a cloudy gray magma, in which are scattered very profusely small fragments of quartz. Large scales of biotite mica, permeated in all directions by smaller scales of the same, make up the remaining ingredients of the rock. Much of the mica is changed to chlorite. Comparing this specimen with No. 1051, a mica schist from the high cliffs, eight miles west from Dog river, on the main land, we find that they are almost identical in appearance and composition. Their color in the hand sample is the same as well as all of their macroscopic characteristics. Under the microscope we find the same similarities. The magma differs slightly, but it is very similar in both. The size and relative amount of quartz grains in the two are the same. The mica in No. 1051 is more altered and is not aggregated into such peculiar masses. Perhaps the most noticeable difference is the presence of a few small crystals of triclinic feldspar in No. 1051, but this can be explained by the proximity of the eruptive No. 1050.

Another interesting example is a boulder of mica diorite which is also common in the conglomerate. The plagioclase occurs as very numerous small elongated crystals, permeating the section in all directions. These have been slightly altered, but can be readily identified. The mica has for the most part disappeared, chlorite taking its place. This rock can also be readily referred to the igneous form, No. 1050, which occurs at the same cliffs, interbedded with the schists. As in the preceeding case the chief differences lie in the de-

gree to which they have decomposed, the ingredients being exactly the same in the two specimens. Felsite porphyries are very numerous in this conglomerate, occurring in well rounded boulders. The magma is dark red in color, frequently showing fluidal structure. In many of the specimens minute grains of quartz have almost entirely replaced the matrix. Quartz crystals of any considerable size are rare in many of the specimens. Orthoclase crystals, with regular form, but much altered, are present in large quantities. These porphyries resemble closely No. 1019, already described, which occurs at Dog river, on the mainland. The matrix in which these boulders are imbedded varies greatly, according as it approaches the diabase No. 1088, which completely covers it. Small crystals of quartz, orthoclase and plagioclase, which are remarkably free from alteration, calcite, together with a few small fragments of much altered diabase, and several other ingredients which could not be identified, make up the mass of the rock.

The conglomerate which occurs at cape Choyye is made up entirely of loosely compacted grains, quartz and feldspar being the principal ones. There seems to have been no such action of heated matter at this point, as on the island where capped by diabase, nor do boulders of such size here occur. As seen from the above, the observations of Irving, in regard to these conglomerates, do not seem here to apply. For as we have said, there are boulders of three distinct kinds in the conglomerate on Michipicoten island, which have no parallel in the rocks occurring there, but can be easily referred to the older Lawrention and Huronian.

The quartz porphyries which occur about one mile south-east from the mines toward the center of the island appear to be closely related to the conglomerate described above and have all the appearances of being simply this conglomerate fused by the overflow of the diabase. Our data are too meager to make this anything more than a suggestion. A careful study of the ground and patient tracing of contact zones are necessary before anything can be positively affirmed of these. The weathering to which these rocks have been subjected, renders the problem all the more difficult, as in many places soil several feet thick has been formed.

No. 1099 (Plate XIII, Fig. 1.) is a typical illustration of these porphyries. It is of a very dark red color. Crystals of quartz and orthoclase, averaging about a sixteenth of an inch in size, are regularly distributed throughout the specimen. The magma is light red in color

in the section and completely felsite. The figure shows one of the quartz crystals cut exactly transversely. The only other conspicuous ingredient is orthoclase. This occurs in crystalline form, frequently in baveno twins, but never unaltered.

No. 1099b is found a short distance from the above. It is of lighter color than No. 1099a, and has a more distinctly conchoidal fracture. Large crystals of quartz, about an eighth of inch wide, and decomposing feldspar crystals of light reddish color, one-fourth of an inch in diameter are readily distinguished. The quartz crystals are regularly filled with inclusions. Besides the larger crystals of quartz, there are present smaller grains in large quantities, these latter of about the same relative size. There is no free iron oxide present in either specimen. Besides these two typical porphyries, there are two other kinds, which on account of their weathering can not be satisfactorily studied. One coarsely granular variety is light red, with whitish grains, (orthoclase ?), scattered throughout it. These grains can not be identified because of their decomposition. This rock has the characteristics of a porphyry, but greatly resembles, superficially, the conglomerate. The other, occurring but a short distance from No. 1099b, is apparently fragmental, but the fragments are angular and irregularly aggregated, and in section appear like the felsitic magma of the adjacent porphyry. No critical examination even of our inadequate material is now possible.

In conclusion, then, the north shore of lake Superior presents three distinct groups of rocks with their respective intrusives, which may be designated as granitic, schistose and conglomeritic. The granites are coarsely granular and contain small amounts of hornblende or mica and are occasionally augitic. The quartz is in large amount, while plagioclase is often present. These granites are found underlying the schists in such a way as to suggest that they have been intruded beneath them, though of course the material must have previously existed. That the material was granitic is indicated by the fact that precisely similar granites associated with felsites constitute the pebbles of the basement conglomerates in the schists. The origin of this older granite is unknown, but it would seem that it occurred in the same way as the existing exposures beneath sedimentary or other masses which have been used in the formation of the schists.

The eruptives found perforating the granite are all diabases. It is not denied that there may be felsite dykes, but none were observed.

The schists have been fully described. There are constantly metamorphosed at contact with the granite and are perforated by dykes of diorite and felsite in the stratification, the former being derived from the fused lower part of the schists, the latter from the upper part of the granite more or less modified by contact with the schist. The schists and schist-conglomerate especially have in several places been altered to porphyry and felsite-porphyry by contact with the eruptives with or without obliteration of the schistose structure.

The third group consists of basement conglomerates consisting of fragments of all the varieties of rock included above, which it is possible to trace to their immediate source in the high cliffs adjacent. Periodic overflows of igneous matter have left vast sheets of diabase, diabase-porphyrite, and diabase-aphanite, varying into so-called ash-bed diabase, distributed irregularly with amygdaloids and pseud-amygdaloids in great variety. These flows were often apparently sub-aquatic and the strong interaction between the sedimentary and eruptive in presence of superheated steam or slowly percolating water has caused the concentration of metals along contact zones of the amygdaloids. The great quantity and area of the overflows caused extensive fusion in the conglomerates in places, possibly producing a part of the quartz-porpyry and porphyritic conglomerates. The large quantities of calcite in this whole series is taken as proof of its essentialiy metamorphic character (in the sense of local derivation from existing materials.) There is no evidence in this region that there were extensive eruptions of acid rocks to furnish the materials for the clastic members, all the conglomerates being easily derived from the adjacent cliffs of granites and schists. No gabbro or allied rock which could be identified as an eruptive of Keweenaw age was seen. It is evident that a very considerable interval must have elapsed since the disturbance of the schist prior to the formation of the Keweenaw conglomerates lapping upon them. Erosion of enormous extent must have gone on and the materials may have been transported far into what is now the bed of lake Superior. If this be the case, of course the base of the Keweenaw is not exposed at all, but is situated far southward and the marginal part very likely displays very different characters from that nearer the axis of depression.

We desire, finally, to acknowledge the kindness of the Hon. Robert Bell, the distinguished geologist of the Canadian Geological Survey, for literary aids, and to disclaim any hope to do more in this pa-

per than point out a few simple facts and certain more or less presumptive inferences bearing on that most interesting problem, furnished by the Azoic system.

PLATE X.

Fig. 1. Diabase porphyrite, No. 1882.]
Fig. 2. Felsite porphyry, No. 1066.

PLATE XI.

Fig. 1. (No. 1001.) Section of chloritic schist just east of Dog river. A closely granular magma of quartz, feldspar and calcite, with large irregular crystals of calcite (*c*), mica flakes (*m*), quartz grains (*Q*), and scattered magnetite and hematite.

Fig. 2. (No. 1008.) Section lenticular felsite-porphyry, occurring in the schist, showing fluidal arrangement of the magma, *L*. orthoclase and oligoclase. *Q*. quartz.

Fig. 3. Diabase porphyrite (No. 1082.) from southwest coast Michipicoten island. (See Plate X, Fig. 1.) *y*. labradorite, *a*. augite, *x*. apatite, 3a. portion of magma highly magnified, 3b. vesicles from same, 3c. crystals and twins of plagioclase from same, 3d. isotropous section of apatite from same.

Fig. 4. From a dyke (No. 1004.) one half mile northeast of Dog river. *o*. orthoclase, *p*. plagioclase, *a*. augite, *x*. peculiar green amorphous grain. Much magnetite.

Fig. 5. Diagram of felsite veins in schist, east of Dog river, (Nos. 1008 and 1009.)

Fig. 6. Diagram of contact between Nos. 1019 and 1019a. No. 1019, porphyryritic phase of schist, 1019a. fine-grained diabase porphyrite.

Fig. 7. Section through strata at west end of Michipicoten island. C. coarse basement conglomerate. F. banded fine-grained sandstone in C. X. Contact zone of conglomerate, (cupriferous) 10 feet. T. Amygdaloidal trap, 40 feet. A. vesicular amygdaloid 33 feet.

Fig. 8. Hypothetical section through Michipicoten island, along line A-B., figure 9.

Fig. 9. Outline map of Michipicoten island, (not accurate) with position of numbers in our series and supposed lines of strike.

PLATE XII.

Fig. 1. (No. 1011b.) See p. 126.
Fig. 2. (No. 1011a.) See p. 126.
Fig. 3. (No. 1011c.) See p. 126.

Fig. 4. (No. 1056.) Section of diabase from large dyke cutting the point next west of Eagle river.

Fig. 5. A. (No. 1018.) Chlorite scales.

Fig. 5. B. (No. 1018.) pseudomorph of chlorite after mica.

Fig. 6. Baveno twin of orthoclase from granite No. 1059.

Fig. 7. (No. 1088.) Diabase-aphanite capping the conglomerate near west end of Michipicoten island. The conglomerate extends 30 feet above the water's edge and is covered by the aphanitic phase of 1088, which becomes more porphyritic above. The conglomerate is itself altered to a porphyry near contact.

Fig. 8. Twin of augite from dyke (No. 1111.) at west side of Dog river at its mouth. *a.* augite, *f.* feldspar, *m.* magnetite, *u.* uralite.

Fig. 9. Conglomerate near Dog river, (No. 1023.) pebbles being 12 inches in diameter. From a photograph.

Fig. 10. Diagram of supposed geological structure of lake Superior, partly after Irving. A section through Michipicoten island and and Keweenan point.

PLATE XIII.

Fig. 1. Section of the porphyry No. 1099a, with a slightly corroded isotropous transverse section of quartz.

Fig. 2. No. 1087a. Altered mica schist as a boulder in 1096.

Fig. 3. Pseud-amygdule from 1077, with concentric ferruginous bands.

Fig. 4. Pseud-amygdule in 1091.

Fig. 5. Augite twin in granite No. 1107, near contact. *f.* feldspar, *q.* quartz.

Fig. 6. Highly magnified portion of No. 1019a. Diabase porphyrite at Dog river, with grouped crystals of titanic iron.

Fig. 7. Section of No, 1082a. with concentric pseud-amygdules of chlorite in stellate polyhedral aggregates. *f.* plagioclase. The black is magnetic.

Fig. 8. Altering crystal of plagioclase in 1083.

Fig. 9. A. map of region about Michipicoten river, north shore of lake Superior. B. Section along A B in above map.

VI.

Sketch of the Geological History of Licking Co.—No. 2.

Additional Fossils from Coal Measures at Flint Ridge.

(Plate XIV.)

Opportunity has been afforded to examine a few additional specimens from the shale above the cannel coal at Flint Ridge, among which are the following:

1. *Lingula scotica*, Dav. (var?) (Plate XIV, Fig. 15.)

Our only specimen is a fragment, agreeing pretty closely with the form from the Waverly identified with this species by Meek (Pal. O. Vol. II, p. 276.) If Meek's figure is accurate the Waverly species has quite a different outline from the Scottish, as figured by Davidson, (Carb. Brach. vol. IV, part III, plate XVIII, Fig. 5.) The latter also says, "Beak extremely attenuated and acutely pointed at its termination." *L. scotica, var. nebrascensis*, Meek, though much smaller, has more distant striæ. It is probable, judging from the fragment, that our specimen had nearly the form of the European.

2. *Lingula umbonata*, Cox. (?) (Plate XIV, Fig. 2.)

The species resembles some varieties of *L. squamiformis*, Phillips, while *L. melie* H., as figured from the Waverly by Meek, resembles closely some forms of *L. mytiloides*, Sow. Specimens of L. melie in our collection, however, show the very prominent mesial ridge characteristic for that species. L. tighti, from the cannel coal a few feet below the present horizon, unless all specimens examined were distorted, differs very greatly in outline, (see Plate IV, Fig. 5.) In size specimens under consideration agree exactly with the Indiana specimens of L. umbonata, but are proportionally wider, especially above the middle.

3. *Discina convexa*, Shumard. (Plate III, Fig. 9.)

4. *Discina nitida*, Sow. (Plate II, Figs. 8-9.)

(Discina meekiana, Whitfield.)

This species, if not identical with the European, is a very close vicarious form and ought probably to be ranked as a geographical variety. Some of our specimens show the radiating markings figured by Davidson (l. c. supl. Pl. XXX), and differ chiefly in the somewhat more central position of the beak.

5. *Edmondia* (?) *reflexa*, MEEK, (Plate XIV, Fig. 21.)

Only the exterior of the valves has been seen.

6. *Pleurophorus immaturus*, sp? n. (Plate XIV, Fig. 17.)

There would seem to be constant differences between the small compact form referred to on page 35 and *P. subcostatus*, M. and W., which proves to be very abundant and typical. A considerable series of the latter has been obtained with constant characters.

While far from sure that the smaller form is not the young, it may be best to distinguish it. The lower anterior margin is more abruptly curved and the lower margin convex. The width is over one-half the length, while in P. subcostatus it much less. The radiating striæ also cover a larger part of the shell, which is more convex.

7. *Placunopsis carbonaria*, M. and W., (Plate XIV, Fig. 27.)

A specimen from the locality ofMeek's *P. recticardinalis* is, like the one figured in the O. Pal., a cast of the interior, but has the beak nearer the posterior rounded ear. The markings seem to be characteristic and not accidental. Meek's conjecture of the identity of these species seems correct.

8. Cf. *Pseudomonotus radialis*, MEEK, Pal. Neb., Plate IX, Fig. 3. (Plate XIV, Fig. 26.)

A single left valve resembles that figured by Meek, but has coarser distant radiating lines with finer striæ implanted between. The posterior wing is imperfect at the very top. The generic reference is doubtful.

9. *Schizodus curtus*, M. and W. (Plate XIV, Fig. 20.)

This small species is represented by both valves in connection, which agree quite as well with S. rossicus, however, as the species to which they are referred.

10. *Schizodus subcircularis*, HER. (Plate XIV, Fig. 18,) a cast.

11. *Avicula* (*Gervillia*) *ohioense*, HER. (Plate XIV, Fig. 22.)

A specimen apparently identical with those on which the species was founded is somewhat better preserved than those previously figured. The outline is nearly exactly that of Pterinea pintoensis, Walcott, but it is not covered by strong ridges as in that form and possesses the external ligamental groove (?) It is very likely that our species belongs to Leptodesma or at least in that section of the Aviculidæ.

12. *Allorisma costata*, M. and W. (Plate XIV, Fig. 25.)

We have thought best to illustrate the largest specimen of this species yet obtained, which it is hard to identify with the specimen figured in O. Pal. vol. II, Fig. 6, plate XIX.

13. *Myalina sp.* Plate XIV, Figs. 1, 1a.)

This fine species was secured too late for study, but is perhaps new.

14. *Myalina ? sp. ?* (Plate XIV, Fig. 24.)

This species likewise is not identified, it resembles a Modiolopsis more than any carboniferous genus with which it has been compared.

15. *Nautilus forbesianus*, McChesney, (Plate XIV, Fig. 13.)

The fragment drawn is from Mr. Foerste's collection and is sufficient to indicate the species. A very much larger species is also indicated by mere fragments.

16. *Goniatites* (?) cf. *G. iowensis*, M. and W. (Plate VIII, Fig. 11.)

The cast does not even show the presence of septa and the generic reference rests only upon a general resemblance in form to the very flat species quoted.

17. *Dentalium sp?* (Plate XIV, Fig. 12.)

This closely resembles *D. canna*, White, but has more oblique striations and aperture. Apically the longitudinal striations are strong, but toward the aperture they disappear and the concentric striæ appear. The section seems to be naturally oval, though the specimens are all somewat flattened.

17. *Conularia newberryi*, Meek (?) (Plate XIV, Fig. 14.)

A fragment of a large Conularia indicates a fine large species with much finer striæ than C. missouriensis, as figured in Pal. Ill. vol. 5, but agreeing well with the figure given by Walcott, under that name, but which should probably be identified with C. newberryi. The specimen is interesting because of the rarity—almost absence—of shells of this genus from the American coal-measure rocks, The cos-

tæ in this species are acutely prominent and are separated by wider depressions (about 24 to the inch) and are apparently not striate or crenulated.

18. *Euomphalus subquadratus*, (Plate XIV, Fig. 9.)

Quite common.

19. *Loxonema sp?* (Plate XIV, Fig. 8.)

This shell is an almost exact miniature of that figured Plate III, Fig. 2. Although both have the same number of volutions, yet that one is three and one half times as large. In the present species the plications are more numerous and scarcely oblique. There are ten volutions in a shell seventeen millimeters high. About nine or ten plications are visible on one side of the lowest volution. The spire is moderately slender. Diameter of lower volution about five and one-half millimeters. *L. rugosum*, M. and W., has larger volutions. *L. strigillatum*, Dekon., is similar, but is more slender and has more numerous plicæ. Should this species prove undescribed it may be called L. plebium and the large form figured on Plate III, Fig. 2. L. plenum.

20. *Macrocheilus* (*Soleniscus*) *fusiformis*, HALL? (Plate XIV, Fig. 7.) Although much tempted to identify this with S. klipparti, Meek, it would then be necessary to modify the description greatly, for Meek says, "spire, with its lateral slopes, concave above and convex below; volutions six to nine, the upper five or six being very compactly coiled, and forming comparatively but a small part of the entire shell," neither of which statements apply to our form. Fig. 4, of Plate XIV, seems to be *S. medialis*, M. and W. and Figs. 5 and 6 most nearly resemble *S. planus*, White.

PLATE XIV.

Fig. 1. *Myalina sp.?*
Fig. 2. *Lingula umbonata*, Cox; two valves in connection.
Fig. 3. *Straparollus?*
Fig. 4. *Soleniscus medialis*, M. and W.
Fig. 5. *Soleniscus planus*, White?
Fig. 6. Probably the same species as Fig. 5.
Fig. 7. *Soleniscus fusiformis*, Hall.
Fig. 8. *Loxonema plebium*, sp. n.
Fig. 9. *Euomphalus subquadratus.*
Fig. 10. *Orthonema?* sp.
Fig. 11. *Goniatites iowensis*, M. and W.
Fig. 12. *Dentalium* sp.
Fig. 13. *Nautilus forbesianus*, McChesney.
Fig. 14. *Conularia newberryi*, Meek?
Fig. 15. *Lingula scotica*, Davidson.
Fig. 16. Unidentified.
Fig. 17. *Pleurophorus immaturus*, sp, n.
Fig. 18. *Schizodus sub-circularis*, Her.
Fig. 19. *Schizodus*, cast of a very convex species.
Fig. 20. *Schizodus curtus*, M. and W.
Fig. 21. *Edmondia (?) reflexa*, Meek.
Fig. 22. *Gervillia ohioense*, Herrick.
Fig. 23. Tooth of fish?
Fig. 24. Myalina (Modiolopsis?)
Fig. 25. *Allorisma costata*, M. and W.
Fig. 26. *Pseudomonotus* sp?
Fig. 27. *Placunopsis carbonaria.* M. and W.

VII.

THE CLINTON GROUP OF OHIO.—PART III.

BY A. F. FOERSTE.

BRYOZOA.

The Clinton Group of Ohio is remarkable for the fine preservation of a series of *Ptilodictyonidæ* of rather large size, and for the meagre representation of all other families of the bryozoa. In 1875, Hall and Whitfield described five species from the Soldiers' Home Quarries, in Ohio Paleontology, Vol. II. In 1878, U. P. James described two species, in The Paleontologist, No. I, in 1879, three more in No. III, of the same periodical; these specimens were collected in Clinton county, at an exposure three miles north of Wilmington, along Todd's Fork. In 1882, Hall described seven species, in Indiana Geol. Surv. 12th Ann. Report; the basis of these descriptions was some drawings and antiquated notes left by Mr. Van Cleve; the specimens were collected at Dayton, probably in the region of the Soldiers' Home Quarries. The drawings of Mr. Van Cleve were the work of an artist, rather than the careful copy by a naturalist of the specimens at hand. His bryozoa, however, are readily enough determined. These publications have given rise to quite a little synonomy considering the small number of species involved; our large collections, however, from the original localities will readily unravel any confusion that may exist.

In the following pages the system of classification used is that of Mr. E. O. Ulrich. This necessitates the change of many generic references. Unfortunate as this may be, when a name has become familiar and has been universally adopted, it is necessitated by very clear and universally recognized facts. The description of bryozoa has until recently consisted chiefly of the characterization of the external features of the specimen. Specimens of very different structure have often been associated together in incongruous genera, on the evidence of external features alone. In consequence also of that system of classification, generic values were ill understood, and types of genera could not prove a key to the situation. The new method has sought to furnish a scientific basis to this artificial classification, and an unflinching application of the universally recognized rules applying to the type species of genera, has made the avoidance of such changes simply impossible. In view of these facts it is rather amusing to notice the feeling among many of our American paleontologists that Mr. E. O. Ulrich is unsettling the foundations of the classification of bryozoa, when, in fact, he and the prominent European students of bryozoa, are merely doing all they can to give us a firm basis. Mr. Ulrich has assisted me so much in the investigation of bryozoa, by advice, criticisms, the presentation of specimens and the investigation of my own, that I can only express general indebtedness.

FENESTELLIDÆ, King.

Zoaria reticulated by the anastomosing of stems, or fenestrated by the coalescence of the short non-poriferous branches of adjacent stems, the dissepiments. Poriferous on one side only ; the cells sub-tubular, their mouths rounded.

Genus PHYLLOPORINA, Ulrich.

Zoaria flabellate, perhaps infundibuliform when entire, consisting of anastomosing stems which form elongated, irregular meshes. Sections made transversely at some distance from the poriferous side show only one kind of cells. Sections passing just beneath the surface seem to pass through short interstitial cells, which are closed at the surface. Species of this genus have usually been referred to *Retepora, Lamarck.*

I. PHYLLOPORINA ANGULATA, *Hall.*

(*Plate* XV, *Fig.* 1; *Plate* XVII, *Fig.* 1.)

Retepora angulata ?, Hall and Whitfield (*R. Daytonensis* proposed), 1875; Ohio Pal. Vol. II, p. 111.

Retepora angulata, Hall, 1882; 12th Ann. Geol. Rep. Indiana, p. 269.

Frond found in flabellate fragments, originally perhaps infundibuliform, reticulated by the anastomosing of the dichotomously dividing stems, forming elongated fenestrules, which are of small size towards the base of the frond, increasing in size above; fenestrules from the same portion of the frond of about the same size. Poriferous side strongly convex, the non-poriferous side much less convex, and finely striated longitudinally. The cells are separated only by the cell-walls below, above they become constricted, opening upon the surface as small, rounded apertures which are more or less removed from each other, the intermediate portion seems often to be occupied by short interstitial cells not visible at the surface. The cells are arranged in four rows along the stems, the lateral rows opening directly upon the fenestrules. Cross-sections show that the two lower rows arise along the middle of the non-poriferous side and extend along the same to the lateral apertures, the two middle rows arise very near the origin of the lower rows, and open along the upper side of the stem. Partition walls extend longitudinally between the cells; in division, the middle wall usually divides dichotomously and terminates at the origin of the new branches, the two lateral walls form the central partition wall of the new branches; the lateral partition walls in the branches seem to arise from the middle wall by lateral division. During anastomosis, one or the other of the stems seems to prevail and to give direction to the cells of the new structure.

The ordinary variety of this species is of common occurrence, and is characterized by rather stout stems anastomosing at comparatively short intervals; another variety with equally stout stems has much more elongated fenestrules, 3 mm. or even more in length. The variety for which the name *R. Daytonensis* was suggested has very narrow branches, about .25 mm. broad, forming fenestrules 2.5 mm. long. This form is said to differ from the typical forms of *Ph. angulata* in "not possessing the angular ridges between the pores, and in having the borders of the pores elevated, forming the spur-like projections which that species does not show." In our specimens a nodose ridge

along the middle of the stems is very evident. A similar ridge seems to extend along either side, thickening the inner side of the lateral rows of cell apertures. Since the alternate arrangement of cells is not regular, the lower cells are often brought beneath the upper ones, and then give them the appearance of having "a spur-like lip" on the lower side; and again, when these specimens are not free from the surrounding rock they may appear to have only two or three rows of cells, and this same arrangement may give the false impression that the cells "of the lateral ranges have the outer lip extended and elevated, bringing that side of the margin to a level with the inner margin." About 7 cells are found in a distance of 2 mm.

Locality and position. Soldiers' Home Quarries, Brown's Quarry, Fair Haven, Todd's Fork, Clinton Group.

Genus HEMITRYPA, Phillips.

Zoaria infundibuliform, poriferous on the inside, with branches nearly straight and connected at regular intervals by non-poriferous dissepiments. Cells in two rows, separated by a thin median keel. The keel is supplied with elongated tubercles above; from the columns thus formed, slender lateral processes extend on either side to the centre of the space between the keels, where they are united into a delicate network, forming two series of openings between each pair of keels, the openings corresponding in number to the cells beneath.

II. Hemitrypa Ulrichi, *sp. n.*

(*Plate* XV, *Fig.* 2; *Plate* XVII, *Fig.* 2.)

Frond infundibuliform below, broad and horizontally expanded above, the edges in large specimens decumbent. Diameter of the largest specimen seen, 40 mm; but fragments indicate that the specimens may attain a width of even 60 mm.

The poriferous side rarely shown and even then the pores are usually obscured by a peculiar network which is stretched above them. Branches with a median keel along the summit of which, situated at regular intervals, are a number of prominences from which slender processes extend horizontally to the centre of the space between the keels. The processes of adjacent branches unite along the middle of the space between the keels, forming a net, the circular openings of

which usually alternate between the keels of adjacent branches, but are opposed when situated on opposite sides of the same keel. The mesh-work thus formed is very beautiful. The openings correspond in number and situation to the cells beneath. Microscopical sections show the cells to be angular below, becoming rounded and circular above, and opening laterally upon the sides of the branches. About three cells occupy the length of a fenestrule.

The non-poriferous side forms the upper or inner face of the frond, and is the face usually presented. The branches are of medium size, from 5 to 6, usually 5.5 in the width of 2 mm, remotely bifurcated, connected by dissepiments. Dissepiments strong, two-thirds as wide as the branches, in some cases wider, in others narrower, about 4 to 4.5 in the length of 2 mm. The branches appear smooth in perfect specimens, slightly striated longitudinally in worn specimens. The fenestrules are oblong in form, the corners rounded.

Named in honor of Mr. E. O. Ulrich, to whose kind assistance I am in many ways indebted.

The keels of *Hemitrypa dubia, Hall*, are connected by continuous transverse bars ; this species is therefore a member of the genus *Unitrypa, Hall*, and our Clinton species is undoubtedly the oldest species of *Hemitrypa* known.

Locality and position. Brown's Quarry, Clinton Group, common.

PTILODICTYONIDÆ, Zittel.

Zoaria consisting of compressed branching or simple leaf-like expansions, composed of two layers of cells, grown together, back to back, by the adhering of their epithecal laminæ. Interstitial cells, when present, never in the form of vesicular tissue.

Genus CLATHROPORA, Hall.

Zoaria consisting of dichotomously dividing branches which anastomose at fairly regular intervals, forming a flabellate fenestrated frond. Interstitial cells entirely wanting.

III. Clathropora frondosa, *Hall.*

(*Plate* XV, *Fig.* 3; *Plate* XVII, *Fig.* 3.)

Clathropora frondosa, Hall, 1882, 11th Indiana Geol. Report.

Fronds flabellate, composed of branches which divide dichotomously at short intervals, forming short curves, which come in contact again, coalesce, and divide as before; by this means a fenestrated frond is produced, which would alternately consist of a series of short free branches or a series of rings along the growing edge, if the growth were regular. In that case the fenestrules would be also arranged in a concentric series of rows, the rows containing one more fenestrule after each reunion of the branches. As a matter of fact, bifurcation does not proceed in so regular a manner, but still enough regularity exists to place the fenestrules in something like lines or curves, which are often very striking. The fronds expand rapidly above, the sides forming broad, outward curves, the anterior edge being broadly rounded. The fenestrules are comparatively small, oval or even circular in shape. The cells are quadrangular, rhomboidal or hexagonal in form, never typically elongated. From 7 to 8 cells occupy a length of 2 mm. The number of cell-rows on the branches varies from 8 to 17. The fenestrules are also variable in size, an average size being 2 mm, varying to 3 mm. The fronds frequently become very large, attaining a length and breadth of 200 mm. The base of the fronds in the two specimens which alone preserved this portion was observed to be broadly rounded just beneath the first fenestrule, indicating that the frond was attached by the stipe to an articulating base; the latter has not been identified in our collections.

Locality and position. Soldiers' Home Quarries, Centreville, Clinton Group.

IV. Clathropora Clintonensis, *Hall and Whitfield.*

(*Plate* XV, *Fig.* 4; *Plate* XVII, *Fig.* 4.)

Clathropora Clintonensis, Hall and Whitfield, 1875; Ohio, Pal. Vol. II.

Fronds very similar to the last, the fenestrules varying from 2 to 5 mm. in length; typically they are of larger size than those of *C. frondosa*, and are more elongated and irregular in form, varying from oval to ovate, sub-rhomboidal, or even irregular in outline, the upper part

of the fenestrules being frequently more or less acute. The comparative width of branches and enclosed fenestrules has no specific value whatever, the character of real importance being the form of the cells, which are elongated oval in form, the length equalling about twice the width. The cell apertures are arranged between quite prominent longitudinal ridges. From 6 to 7 cells occupy a length of 2 mm. The base of the only frond preserving this feature seems to pass without interruption into a stipe about 4 mm. broad and 18 mm. long, towards its origin the base becomes rapidly attenuated and may have articulated with some expanded, rooting structure. Until more specimens of this kind are discovered, this feature can have no value.

Locality and position. Soldiers' Home Quarries, very common at Fair Haven, Clinton Group.

Genus PTILODICTYA, Lonsdale.

Zoaria wedge-shaped below, above expanding into an undivided leaf-like expansion. The cells are arranged in diagonal cross-rows or have a plumose arrangement, diverging in rows from central longitudinal series of cells, which usually are of smaller size. Interstitial cells wanting. A non-poriferous margin occurs in most species, this if present in the following species must be very narrow.

V. Ptilodictya expansa, *Hall and Whitfield.*

(*Plate* XV, *Fig.* 5; *Plate* XVII, *Fig.* 5.)

Phænopora (Ptilodictya) expansa, *pars*, Hall and Whitfield, 1875; Ohio, Pal. Vol. II. Plate V. fig. 1, is a specimen of *Phænopora platyphylla*, *James*, 1879.

Ptilodictya expansa, Hall, 1883; 12th Indiana Geol. Rep. The original description is here republished, but Plate 12, figs. 2 and 3 are correctly identified.

Frond arising from a wedge-shaped base, gradually enlarging, forming lanceolate expansions, or elongated oblong forms with parallel sides. Epithecal membrane marked by lunate lines of growth along the mesial series of cells, their convex sides directed forward; along the sides of broad specimens there are often longitudinal wrinkles, perhaps indicating that these specimens were derived from the narrower forms by lateral growth. Along the middle of the frond extend from 4 to 7 longitudinal series of cells, which are always con-

spicuously narrower than the lateral rows, in sections made just above the epithecal membranes. The central cells often show a tendency towards a secondary horizontal arrangement, the lateral cells however have also a well-defined secondary diagonal arrangement, diverging from the central rows of cells at an angle of about 15° above a line drawn horizontally across the surface of the frond. The smaller size of the mesial cells, and the diverging cells on either side give the frond a leaf-like or rather a plumose arrangement which is very characteristic.

Cells angular below, quadrangular or rhomboidal; rounded at their apertures, oval or almost circular; arranged between longitudinal raised lines. Fragments of variable size have been found, often 70 mm. long, without any evidence either of base or apex. Full grown specimens were probably 15 to 20 mm. in length. The broadest specimen with perfectly parallel sides seen was 16 mm. broad: the broadest specimen of those of more irregular form measured 25 mm. from the mesial series of cells to the lateral edge, the entire width therefore was probably 50 mm. Mesial cells usually number 14 to 16 in a length of 4 mm; lateral cells, 10 to 14 in the same length. From 17 to 19 lateral cells occur in a width of 4 mm. The mesial cells are narrower than the lateral cells, but the degree of narrowness is variable.

There is not the least doubt of the identity of the first figure published with *Phœnopora platyphylla, James*, a form related to *Ph. constellata, Hall*, with which species, indeed, the authors compared our Ohio specimens. But the identification made by Hall, among the figures prepared by Van Cleve, evidently shows that the authors had an elongated species in mind which they considered typical.

Again most of the distinct features mentioned in the original description are those of *Ptilodictya expansa*. These are: "fronds forming . . . elongate stipes, . . . the lateral edges are . . generally parallel, . . . thin longitudinal partitions . . . slightly raised above the upper and lower walls of the cells, . . . cells . . . in horizontal, or nearly horizontal, rows, diverging from the *central partition* at an angle of about fifteen degrees above a horizontal." The reference to "maculæ" is of course a description of features belonging to the specimen of *Phœnopora platyphylla* figured. There is some doubt as to the meaning of the words "central partition" which I have italicised. If these refer to the narrow mesial cell

rows, the description is intelligible and pertinent ; if not, it has no tangible meaning for either species. We believe that in this case, where we have two generic references, a description including characteristics of two species, and figures of two species, it is most advisable to make the original description the material from which to unravel the form which is to be considered authentic.

Locality and position. Forms with parallel sides are found frequently at Todd's Fork, Clinton county, and rarely at the Soldiers' Home Quarries. Broader forms with less regular sides are common at the Soldiers' Home Quarries. Clinton Group.

Genus PHÆNOPORA, Hall.

Zoaria forming simple or branching fronds without a distinct nonporiferous edge; the pores of the edge seem to be of the same rank with the interstitial cells. Cells arranged in longitudinal series, separated at their ends typically by two interstitial cells, although their number may be so increased in different parts of the same frond as to even completely surround the cells. A transverse septum at the base of the cells is also characteristic. The bases of the zoaria are attenuated and rounded, or somewhat pointed, showing that articulation had formerly existed with some fixed base.

VI. Phænopora platyphylla, *James.*

(*Plate* XVI, *Fig.* 1 ; *Plate* XVII, *Fig* 6.)

Phænopora (Ptilodictya) expansa, *pars*, Hall and Whitfield, including Plate V, fig. 1.

Ptilodictya platyphylla, James, 1879, Paleontologist. No. 3.

Ptilodictya bipunctata (Van Cleve) Hall, 1883. 12th Indiana Geol. Report.

Frond beginning with a small, narrow stipe, which at its origin is obtusely pointed, or almost rounded, indicating articulation with some attached base, rapidly widening above into a broad flabellate expansion, the contour in general being rounded, but flexuous in certain places where growth has been irregular; never branched. The surface covered by conspicuous, rounded tubercles, having a tendency to arrange themselves in rows, about six tubercles appearing in a length of 15 mm; sometimes the tubercles have a tendency to be somewhat pointed. The surface is occupied by the cell mouths, which are very small,

circular, or slightly oval, arranged in longitudinal series, about eight in the length of 2 mm. Typically two interstitial cells are found at the extremities of the cells; in some specimens, however, additional interstitial cells appear along the sides of the cell, or even at the extremities, so that the cells are sometimes completely surrounded by interstitial cells. The cell rows are separated by raised ridges, which appear like a narrow line running between the rows and closely pressed by the cells and interstitial cells on either side; or they become quite broad and poorly defined, bearing on their surface all the laterally situated interstitial cells, the mouths of which are apt to be of an elongated rather than circular shape; whenever the interstitial cells become very numerous these separating ridges are apt to disappear entirely in a disordered mass of cells and interstitial cells. All these changes may appear in one and the same species. At the summit of the tubercles one or more cells are apt to be suppressed; their places are then taken by interstitial cells. The edges of the frond are acute; no non-poriferous margin has been observed, but considering the nature of the growth of the species, this is rather to be expected. Specimens are usually found divided in the middle, the epithecal laminæ being exposed, and the celluliferous faces being adherent to the rock in which the specimens were imbedded. The epithecal membrane is smooth, or wrinkled transversely in curves, which to some degree mark various stages of growth, and conform therefore with the general outline of the flabellate frond. Through the epithecal membrane longitudinal lines may be seen, which are the laminæ that separate the cell rows; between these are diagonal lines dividing the surface into small subimbricating rhombs; sometimes short transverse lines intersect the diagonal lines of the rhomb. From the epithecal laminæ the cells diverge to the opposite faces of the frond, making an angle of 65° or more with the epithecal laminæ.

Fronds vary in size; one of the largest specimens seen being 100 mm. broad and 130 mm. long. Eight cells are found in the length of 2 mm; eight or nine rows occupy the same distance measured transversely. The thickness varies from a thin expansion to a frond 2 mm. thick, rarely attaining a thickness of even 5 mm.

The figure accompanying the original description of *Ptilodictya expansa, Hall and Whitfield*, belongs to this species and the description of that species shows that specimens of this species were by mistake used in the determination of its characters. This species is evidently

closely related to *Ph. constellata, Hall,* from the Clinton Group of Canada. A specimen from Hamilton, Ontario, before me, may be distinguished by the fact that the monticules appear only as slightly elevated patches, and the thickness of the frond is reduced to very small dimensions, perhaps .7 mm, and the frond seems to have been of small size. Specimens collected by Prof. N. S. Shaler, however, from Anticosti, Canada, show all the features of our Ohio specimens.

Locality and position. Soldiers' Home Quarries, Allen's Quarry, Fair Haven, Todd's Fork, Clinton Group.

VII. Phænopora magna, *Hall and Whitfield.*

(*Plate* XV, *Fig.* 6; *Plate* XVI, *Fig.* 2; *Plate* XVII, *Fig.* 7.)

Stictopora magna, Hall and Whitfield, 1875, Ohio, Pal. Vol. II.
Stictopora compressa, (Van Cleve) Hall, 1883, 12th Indiana Geol. Report.

Frond beginning with a narrow stipe which is rounded at its origin, indicating that its base was articulating, gradually widening, until it attains a width of about 6 mm, then branching dichotomously. The dichotomous character of the branching is frequently obscured by the unequal development of the branches and by the unequal intervals between the places at which branching takes place. When the specimens exist only as fragments, pieces of fair size may sometimes be found which seem to be portions of lengthened, undivided fronds, and it is very probable that species of this genus have been described as unbranched, simply because the material in hand was fragmentary. The general appearance of the frond varies, therefore, exceedingly, from a long, scantily branched specimen, to one whose numerous branches look like narrow ribbons woven together. The angles at which the specimens branch vary exceedingly, from small angles of only 10°, in which the bending of the branches for even a slight distance is sufficient to make them overlap each other, or assume a parallel direction, to angles of 80° or even 90°. The surface is covered by conspicuous tubercles, usually low, broad, and rounded, but sometimes pointed and well defined, with a less regular arrangement than in the former species, or even scattered; about 5 tubercles usually occupy a length of 9 mm, although this is subject to great variation.

The cell mouths are small, circular, or slightly oval, arranged in

longitudinal series, about eight in a length of 2 mm; ten or eleven of these series are found in a width of 2 mm. The longitudinal series are well defined by thin, slender, raised lamellæ, without the complex structure mentioned in the former species. The lamellæ separating the cells from the interstitial cells appear at the surface like fine threads, connecting the longitudinal lamellæ, and they cross each other at equal distances between the same, thus enclosing two interstitial cells at the ends of the cells. In the tubercles they become more numerous and either surround the cells or entirely supplant the same. The branches are quite thin and flat; the edges are thin and sharp, and are occupied by minute pores or cells, corresponding in size to the interstitial cells and forming only a narrow margin. Interstitial pores are apt to be numerous in the cell rows along the edges of the branches. Specimens usually divided at the centre, showing the epithecal laminæ; these are wrinkled transversely, the wrinkles being lunate in the middle of the frond, and deflected backwards on either side to the margin. The exterior surface is rarely seen.

Fronds vary in size, a well grown specimen being 110 mm. long and 80 mm. broad; the branches vary between 5 and 8 mm. in width, and a form found at Fauver's Quarry occasionally attains a width of 10 mm Their thickness varies between 1.5 and 2 mm.

Locality and position. Soldiers' Home, Brown's Quarry (a narrow variety), and Fauver's Quarry, Clinton Group.

VIII. Phænopora multifida, (*Van Cleve*) *Hall.*

(*Plate* XVI, *Fig.* 3.)

Ptilodictya (sp?) James, 1878, Paleontologist, No. 1. (Name, *P. Welshi* suggested.

Stictopora multifida, (Van Cleve) Hall, 1883, 12th Indiana Geol. Report.

Frond beginning with a narrow stipe, gradually widening until a breadth of 4 or 5 mm. is attained, then branching dichotomously at small angles, the branches remaining parallel. The branches may lie closely together and almost touch one another. They are rarely more than their width apart. The usual form is that of a series of parallel branches forming a sub-triangular frond by means of dichotomous division, the branches at their tip being a fifth or a sixth of their breadth apart, and at the base touching one another, sometimes forming a continuous frond near the stipe, and at other times being open like the

branches above. All specimens seen were divided at the epithecal membrane, which is wrinkled transversely by lines of growth, lunate in the middle, the ends deflected backwards along the sides, the rounded ends of the branches are preserved on some of the specimens. In specimens whose branches have become contiguous and have grown together at the base of the frond, the wrinkles or lines of growth still indicate readily the position of the branches.

Branches thin and flat, the exterior surface not seen, but the cross-sections made gave no evidence of tubercles, and therefore the surface is believed to be flat. Cells oval, arranged in longitudinal series, 8 cells in a distance of two mm, and 10 or 11 series occupying the same distance in breadth. The series of cells are separated by thin, straight lamellæ, which are not intruded upon by either cells or interstitial cells. Interstitial cells, two, between the ends of the cells, becoming more numerous in one or two of the marginal series; the margin is thickly supplied with them, making it poriferous; poriferous margin narrow.

Frond about 75 mm. long and 70 mm. broad. Branches from 2.5 to 4 mm. broad. Cells, 8 in a distance of 2 mm, measured longitudinally, 10 or 11 in the same distance measured transversely.

It will be noted that this species assumes a sort of intermediate position between the last and the following. In fact the difference in the width of the cells and the different manner of branching, both variable factors, alone distinguish them one from the other.

Locality and position. Soldiers' Home Quarries, collection of Mr. Geo. Caswell. Also, Brown's Quarry, a form with more distant branches. Clinton Group.

IX. Phænopora fimbriata, *James.*

(*Plate* XV, *Fig.* 7.)

Ptilodictya fimbriata, James, 1878, Paleontologist, No. 1.
Stictopora Van Clevii, Hall, 1883. 12th Indiana Geo. Report.

Frond arising from a small narrow stipe, attenuated towards the base, expanding gradually above until a width equal to the branches is attained; then branching dichotomously at variable intervals in different or even in the same specimens; the branches usually flexuose, forming characteristic meshes upon the surface of the rock. Surface unknown, but from numer-

ous sections believed to be destitute of tubercles. The branches are quite thin and flat, with sharp edges.

Cells arranged in longitudinal series, about eight in a length of 2 mm. and ten or eleven in the same distance in breadth. Two interstitial cells are found between the ends of the cells, becoming more numerous in the lateral series of cells, and entirely pervading the tissues of the edges of the branches, which as a consequence appear striated in worn specimens. The branches are usually narrower than those of the last species, eight to twelve series of cells occupying the branches in this species, whereas in that species twelve to fifteen series are usually found.

The largest frond so far observed, evidently not an entire specimen, was 65 mm. long, and 50 mm. broad. The branches vary from 2.3 to 3.2 mm, and sometimes attain a thickness of 1.2 mm.

Associated with these species are long, slender fronds, undivided, with the characteristic cells and interstitial cells of the group, the latter pervading the edges of the frond. One specimen is 55 mm. long and 5 mm. broad. They are probably the broken off stipes of some of the species last described. That the species all form a closely allied group may readily be seen.

Locality and position. Soldiers' Home Quarries, Todd's Fork, Fauver's Quarry, Allen's Quarry, Fair Haven, Clinton Group.

Genus PACHYDICTYA, Ulrich.

Zoaria composed of thick, often irregularly branching fronds, with distinct, smooth, non-poriferous margins. The cell walls are distinct and regular, neatly enclosing the oval cells; at their ends they are usually approximate, nearly but not quite touching, the cells being arranged in longitudinal series; laterally, however, they are always separated from each other by two quite thick lamellæ which are continuous between the cell rows, following up the contour of the cells, but separated along the middle by a curved or quite straight line, which sometimes is indistinct. Species of this genus are usually referred to *Stictopora*, but in that genus the cells are separated by a series of small spiniform tubuli.

X. Pachydictya emaciata, *sp. n.*

(*Plate* XV, *Fig.* 8; *Plate* XVII, *Fig.* 8.)

Frond not known in its entire state, only one specimen (and that

a fragment) seen. The specimen is 26 mm. long and 22 mm. broad, being divided dichotomously into branches at angles of about 45°.

The branches are 3 mm. wide and scarcely ⅔ mm. thick. The cells are arranged in longitudinal series, forming at the same time more or less accurate oblique cross-rows. Cells oval, narrow in the middle rows, broader in the lateral rows, about 6 occupying a length of 2 mm, and 11 series the same distance in breadth; 10 to 13 series are found on the various branches. The longitudinal series are separated by raised longitudinal lines, inclined to be flexuose on account of the diagonal lines, in which the cells dispose themselves; occasionally these ridges seem to bear 2 or 3 fine striæ. The margins of the branches show faint traces of striæ.

From the succeeding species it may be distinguished by the thinness of its branches, the wider non-poriferous margin, and the greater number of its cells in transverse measurement. Name signifies *thinned* or *grown thin.*

Locality and position. Soldiers' Home Quarry, Clinton Group.

XI. Pachydictya bifurcata, (*Van Cleve*) *Hall.*

(*Plate* XV, *Fig.* 9; *Plate* XVII, *Fig.* 9.)

Stictopora bifurcata, (Van Cleve) Hall, 1883, 12th Indiana, Geol. Report.

Frond arising from a narrow stipe, attaining the size of the branches above, then branching rapidly below, less frequently above, at angles between 30° and 50°. The branches are convex and decidedly thickened, their thickness exceeding half their width. The surface even and smooth, at least not tuberculate, channeled lengthwise, the cells placed in the channels, five and a half or six found in a length of 2 mm, and six or seven in the same distance in breadth. The cells are oval, slightly separated at the ends by the dividing lamellæ; the longitudinal series are usually separated to quite a marked degree by thick lamellæ, which are marked longitudinally along the summit by faint undulating striæ. The edges of the branches are non-poriferous and smooth, or very indistinctly striate, obtuse, but with a narrow salient margin indicating the position of the epithecal lamina.

The largest specimen found was 160 mm. long and 85 mm. wide; the branches are somewhat flexuose, about 4 to 5 mm. broad, and

from 2 to 3 mm. thick. This form may be compared with *P. acuta, Hall,* from the Trenton Group of New York.

Locality and position. Soldiers' Home Quarries, Fair Haven. Clinton Group.

XII. Pachydictya bifurcata, var. instabilis, *var. n.*

(*Plate* XV, *Fig.* 10.)

Frond known only by fragments 30 to 40 mm. long and broad, branching dichotomously at wide and variable angles. The branches from 3 to 5 mm. wide and from 1 to almost 2 mm, thick; the surface uneven, more or less tuberculated, the tubercles low but generally distinct, without evident arrangement, about 4 tubercles in a distance of 80 mm, measured longitudinally.

The cells are oval, from 6 to 7 occupying a length of 2 mm, usually nearer the latter number, and from 8 to 9.6 rows occupying the same distance in breadth. The non-poriferous edges narrow in the specimens examined.

Whether this form is distinct from the last one, it is difficult to tell. Where there are so many species of a genus, occurring in such abundance, their form is usually very variable, and the distinctions between species are not always well defined. Judging from the specimen at hand, it is difficult and perhaps impossible to distinguish between the forms specifically, and intermediate forms seem to occur.

Locality and position. Brown's Quarry, Clinton Group. The species occurs here in all its forms apparently. The extreme, nodulated or tuberculated forms, which are separated here as a variety predominate.

XIII. Pachydictya turgida, *sp n.*.

(*Plate* XV, *Fig.* 11; *Plate* XVII, *Fig.* 11.)

Fronds variable, branching dichotomously at angles from 30° to 50°; branches more or less thickened, the edges inclined to be obtuse with a salient line along the epithecal lamina, the margin non-poriferous. Cells oval, 12 in a distance of 5 mm, measured along the longitudinal series, 16 series in the same distance in breadth. Two or three faint flexuose lines are found on the ridges separating the series.

The surface is tuberculate; the tubercles are of variable distinctness, and are arranged in something like order, from 4 to 5 in a distance of 10 mm. The tissue in the tubercles becomes very thick, the arrangement of the cells is somewhat disturbed and their number reduced.

The largest fragment at hand is 55 mm. long and 35 mm. broad. The branches vary from 6 to 9 mm. in width, and from 1.8 mm. to 3.5 mm. in thickness.

Name signifies *thick, swollen*, referring to the thickened fronds. This form may be compared with *P. fenestelliformis, Hall*, as identified by Mr. E. O. Ulrich, from the Cincinnati Group of Illinois.

Locality and position. Soldiers' Home Quarries, Fair Haven, Clinton Group.

XIV. Pachydictya obesa, *sp n.*.

(*Plate* XV, *Fig.* 12.)

The structure of this species is very similar to the last, but the fronds are broader, apparently undivided, and usually thicker, forming coarse, often undulating or folded fronds. Tubercles much more distinct, with a more decided tendency for arranging themselves in series, 4 to 5 in a distance of 10 mm. Tangential sections show that the number of cells is decreased in the tubercles by the turgescence of the surrounding laminæ, or by the entire suppression of cells. One of the largest fronds at hand is a fragment 65 mm. long, 37 mm. wide and 5 mm. thick. Some specimens are not so thick, but still thick enough to attract attention to this feature. It may be compared with *P. gigantea, Ulrich*, from the Cincinnati Group of Illinois.

Name signifies, *very thick and swollen, fat.*

Locality and position. Soldiers' Home Quarry, Clinton Group.

CYSTODICTYONIDÆ, Ulrich.

Zoaria consisting of two or more layers, grown together along their epithecal membranes. Cell apertures with a crescentic lip. Interstitial spaces occupied by vesicular tissue, which in the matured stage is almost obliterated by a secondary deposit of sclerenchyma, apparently

perforated by minute, vertical, communicating canals. Margins of zoaria non-poriferous. (Ulrich, Am. Pal. Bry. April, 1884.)

Genus RHINOPORA, Hall.

Zoaria consisting of two laminated expansions, grown together along their epithecal membranes; the margins are non-poriferous. The cell apertures are strongly raised above the surface in little papillæ or pustules. The aperture itself is quite small and usually appears more or less irregular in form, suggesting the crescentic lip so characteristic of the *Cystodictyonidæ* and *Fistuliporidæ*. The interstitial tissue, if any, seems to have been obliterated by the secondary deposit of sclerenchyma.

XV. Rhinopora verrucosa, *Hall.*

(*Plate* XV, *Fig.* 13; *Plate* XVII, *Fig.* 12.)

Rhinopora frondosa, Hall and Whitfield, 1875, Ohio, Pal. Vol. II.
Escharina (?) distorta, James, 1879. The Paleontologist, No. 3.
Rhinopora venosa, Spencer, 1884, Niagara Fossils, St. Louis Acad. Science, Vol. IV, No. 4.
Cf. Rhinopora curvata, Ringueberg, Bull, Buffalo. Soc. Nat. Sc., Vol. V, No. 1.

Fronds forming thin expansions, the defining margins being sharp and distinctly non-poriferous. Specimens usually occur in the form of fragments, smaller pieces of which appear flattish, and some pieces of even fair size may be found with only a moderate amount of curvature. However, when broken from the solid rock, parting along the epithecal membranes, expansions may be followed for 30 mm. or more through the rock, contorted and curved in almost every possible manner. Proper branching does not take place, but the outlines of the fronds are often quite irregular. The character of the base of the frond is unknown. The cells are arranged in diagonally intersecting rows which may be quite straight for a moderate distance, but usually are somewhat curved. This arrangement may be perfectly maintained over quite a large portion of the surface, but frequently is perfect only in small patches, the rows of which do not perfectly join each other, on account of the introduction of new rows, the sudden curvature of

a series of rows, or on account of the disturbing influences of the structure next to be described. Between the cell rows at variable distances over the frond are distributed a number of raised lines which are more or less connected with each other and have the appearance of a branching structure trailing over the surface of the frond. These may become quite conspicuous and form a marked feature of the frond, but they do not seem to have any very intimate connection with the rest of the frond. This they very frequently show by entirely weathering away from the surface of the frond. The place they occupied is then marked by a groove which becomes quite conspicuous in the specimens which were characterized by large raised lines. These raised lines extend along the grooves between the cell rows usually including and resting upon the inner half of the cells between which they extend. Usually they leave the arrangement of the cells unaffected, but the arrangement of the rows may be more or less disturbed in crossing these lines. At the junction of the raised lines, especially where several lines meet, the cells are apt to be more separated at this point than elsewhere on the frond; the cells then frequently become of somewhat larger size, are more prominent, and form slightly elevated clusters of moderate size, over the surface of the frond, which sometimes occur at quite regular intervals and form conspicuous features of the frond. When the raised lines in such specimens were quite narrow and then weathered away, these low elevations are still more conspicuous. The center of the elevations is frequently marked by an irregular, non-celluliferous portion where the lines meet; these spaces then may suggest maculæ. The prominent surrounding cells of the elevated parts are frequently crowded back upon each other for a short distance by the dividing ridges and then also are more inclined to form conspicuous elevations. The apertures of the cells are produced in the form of round papillæ above the surface of the frond. The mouth is situated at the very summit of the papillæ, but may appear more or less lateral by the unequal wearing away of the cells. Near the base on one side of the cell may be found a small depression, the precise nature of which is unknown. It may have had some connection with the interior of the frond, but such connection has not been established. No interstitial tissue has been satisfactorily determined. The cells vary from 50 to 60 in the distance of 25 mm. In *R. tubulosa, Hall*, they are said to be more crowded, numbering from 80 to 85 in the same distance.

This species is seen to be quite variable, but there is no difficulty at all in tracing the connection of the different forms in any collection which contains a large number of specimens in a good state of preservation. As might be expected, its distribution is also quite wide, extending from New York to Ontario and Ohio, and being found both in the Niagara shales and in the Clinton Group.

Locality and position. Brown's Quarry, Soldiers' Home Quarries, Centreville, Fair Haven, Todd's Fork, Clinton Group.

FISTULIPORIDÆ, Ulrich.

This family is closely allied to the *Cystodictyonidæ*, from which it differs in the absence of non-poriferous margins and in having no secondary deposit obscuring the presence of the interstitial cells, or at least, when present, being quite superficial.

Genus LICHENALIA, Hall.

Zoaria composed of a single layer of cells, the epithecal side being concentrically wrinkled, the wrinkles being supplemented by secondary finer concentric striæ; when the epithecal membrane is translucent, the bases of the cells may be frequently seen in the form of short, radiating striæ. Cells with a crescentic lip at the aperture which is continued into the tube of the cell in the form of two longitudinal inflections of the cell walls. Interstitial cells always present, separating the cells.

XVI. Lichenalia concentrica, *Hall.*

(*Plate* XVII, *Fig.* 10.)

No specimens of this species have been found in my own collections, but it is represented by several specimens in the cabinet of Dr. L. B. Welch. The following short description of this species is therefore added.

Zoaria forming circular flattened expansions, often 130 mm. in diameter, celluliferous on one side only, the arrangement of the cells being disturbed in some varieties by the presence of maculæ. Cells

separated by angular interstitial cells. Non-celluliferous face wrinkled concentrically.

Locality and position. Clinton County, Clinton Group, collection of Dr. L. B. Welch.

CERAMOPORIDÆ, Ulrich.

Zoaria usually incrusting, sometimes ramose with hollow branches, or flabellate. Cell apertures triangular or ovate, with a prominent and arched lip usually on one side. (Ulrich, Am. Pal. Bry.)

Genus CERAMOPORA, Hall.

Usually incrusting. Cells angular, with the lip strongly arched, the aperture oblique; cells radiating from one or more centers. (Ulrich, Am. Pal. Bry.)

XVII. Ceramopora expansa, *James.*

(*Plate* XVII, *Fig.* 13.)

Alveolites expansa, James, 1879, Paleontologist, No. 3.

"Corallum, a flat or undulating expansion, irregular in outline, 6 inches or more in diameter, varying in thickness from less than one to over two lines. Corallites very oblique and more or less sinuous in their direction from the base or central axis to the surface. Calices very narrow, slightly curved, elongated slits, showing, generally, when a little weathered, a tooth-like projection in the middle of the upper lip, and arranged sometimes in series of short curved rows in a more or less alternating manner. About 4 calices in the space of a line. Walls of corallites thick.

"Although the specimen from which this description is made was found spread over the surface of a rock—from which it readily scaled off—it is not certain that it was *encrusting*, as there is an appearance of something like a central axis from which the corallites grew in different directions to opposite surfaces, in a very oblique manner; portions of the side next the rock show calices similar to the other

side, but not so distinct, as it is mostly covered by, apparently, indurated clay." (James. *loc. cit.*)

Dr. L. B. Welch very kindly showed me the type specimen in his cabinet. The specimen is very unsatisfactory. The cell apertures were seen to have a strongly arched lip on one side, and were arranged in diagonally intersecting rows, about 5 cells in a length of 2 mm. I should be unwilling to attempt any further statements concerning it, and so have repeated the original description. Its general aspect seemed to be that of a much worn fragment of some species of *Ceramopora*.

Locality and position. Clinton Group, Clinton county; collection of Dr. L. B. Welch.

MONTICULIPORIDÆ, Nicholson.

Zoarium with tubular cells, which are thin-walled and polygonal below, above they are bent more decidedly towards the surface, are of nearly equal size throughout, more or less thickened and rounded, but never lipped nor separated by vesicular tissue. Zoaria usually ramose, occasionally frondose, or forming flat circular or irregular expansions; never composed of two distinct layers of cells entirely separated by epithecal membranes.

Genus PRASOPORA, Nicholson and Etheridge.

Zoarium forming a hemispherical mass or a thin expansion, with a wrinkled epithecal membrane on the lower surface. Cells cylindrical or more or less prismatic, lined on one side with cystoid diaphragms.

XVIII. Prasopora parmula, *sp n.*

(*Plate* XV, *Fig.* 14; *Plate* XVII, *Fig.* 14.)

Zoaria forming thin, flattened expansions which are lined by a wrinkled epithecal membrane on the lower surface; circular when young, later becoming more irregular in outline. Typically the lower

surface is concave, corresponding to the convex outline of the upper surface. Cells of about the same size, occasionally a few are slightly larger in size, but form no distinct feature in the growth of the zoarium. Cell apertures polygonal, but rounded and almost circular, having a tendency to arrange themselves in rows. In the space left between the outlines of four cells is usually an angular interstitial cell not always readily recognized at the surface under a low magnifying power. Cells with cystoid diaphragms along one side, the ends of the same gradually becoming attenuated and almost meeting on the other side of the wall, thus almost encircling the cells. In addition to cystoid diaphragms a number of straight diaphragms are found, which run from the middle of the cystoid diaphragms to the opposite wall. The interstitial cells are also crossed by straight diaphragms, which, however, are far more numerous than those of the regular cells, being usually twice as many or even more.

Cells, about 8 or 9 in a distance of 2 mm; in one specimen about 18 straight diaphragms are found in the length of an interstitial cell, 9 cystoid diaphragms are found in the adjoining cell, most of which are connected with a straight diaphragm also belonging to this cell; since the thickness of this specimen is about 1 mm, a very fair idea of the relative importance of these tissues may be formed. Expansions vary from 20 mm. to 33 mm. in diameter. The name signifies *a little shield.*

Locality and position. Huffman's Quarry, Beavertown Marl; Soldiers' Home, Clinton Group. Todd's Fork, in the upper iron-bearing portions of the Clinton Group; this iron-containing layer, which is here several feet thick, contains almost all the characteristic fossils of the Beavertown marl.

Genus MONOTRYPELLA, Ulrich.

"Ramose, smooth or tuberculated. Cells apparently of one kind only. Walls very thin in the axial portion of the branches, but thicker in the peripheral region. Diaphragms straight. No spiniform tubuli." (Ulrich, Am. Pal. Bry.) The following species is provisionally referred here on account of the apparent absence of interstitial cells.

XIX. Monotrypella confluens, *sp. n.*

(*Plate* XVI, *Fig.* 4; *Plate* XVII, *Fig* 15.)

Zoaria irregularly ramose, branches varying from 5 mm. to 11 mm. in diameter, usually forming coarse, gnarled growths by the irregular confluence of several branches, which are very characteristic of this species. Cells vary from 9 to 11 in a distance of 3 mm; where the surface is well preserved, the margins of the cells are seen to be circular and to be distinctly raised above the surface of the branch. The margins sometimes touch each other on one or more sides, but are just as frequently entirely free and distinct, and never are polygonally compressed. The interstitial spaces left between the raised margins of the cells sometimes have the appearance of small interstitial cells, but usually they appear simply as depressed areas. In worn specimens the raised margins of the cells can not be detected and the inter-cellular spaces then appear simply as thickened cell walls, separating the cells. Tangential sections give no evidence of interstitial cells in such cases, and in longitudinal sections the cells appear to be of one kind only. The cell walls in tangential sections near the surface appear very thick, but only a slight distance from the surface they are seen to be very thin. Straight diaphragms are developed in moderate numbers and are somewhat more numerous towards the surface, but the distinction between the mature and immature portion does not seem to be very great. About 9 diaphragms occur in one of the sections in a distance of 3 mm; the number naturally would vary considerably however. In some specimens in which the surface is free from all sediment, operculate diaphragms seems to extend across the cells a short distance below the surface of the specimen. Some specimens also show low elevations about 3 mm. distant from each other, in which the number of cells seems somewhat reduced. The name refers to the characteristic gnarled expansions formed apparently by the growing together of branches, the latter becoming *confluent.*

Locality and position. Soldiers' Home, Clinton Group.

Genus CALLOPORA, Hall.

"Ramose to sub-frondescent, smooth or tuberculated. Cell-tubes cylindrical, their apertures often closed by an operculum, with a very small central perforation, from which usually radiate small ridges. In-

terstitial cells, more or less numerous, sometimes completely isolating the proper zoœcia. Diaphragms numerous. Spiniform tubuli and cystoid diaphragms wanting." (Ulrich, Am. Pal. Bry.) The following species are provisionally referred here on account of an apparently similar relation between cells and interstitial cells.

XX. Callopora magnopora, *sp. n.*

(*Plate* XVI, *Fig.* 5; *Plate* XVII, *Fig.* 16.)

Zoaria branching at intervals of about 15 mm; branches from 6.5 to 8 mm. in diameter, rather irregular in form and often with low tubercles of no marked characteristics, and which may be entirely absent. Cells about 8 in a distance of 3 mm. Cell apertures sub-circular, the margins not distinguishable at the point of contact, but distinct and elevated along the rest of the cells, apparently enclosing interstitial cells, these appearances obscured by abrasion. Tangential sections seem to give better evidence of interstitial cells, these being smaller, irregular, rather fewer in number, and more or less surrounding the more circular cells. In longitudinal sections the interstitial cells may apparently be also detected, being narrower cells with somewhat more numerous diaphragms. In one specimen there were 10 diaphragms in a length of 1 mm. in the cells, in the interstitial cells 13 or 14 were found.

This species is readily distinguished from the last by the larger size of the cell apertures, being about one and a half times the size of that species. When the number of the cells is approximately the same this may be accounted for by the fact that, whereas in the former species there is a considerable space left between the margins of the cells, in this species they are united into one cell wall, indistinguishable at the surface. The number of diaphragms is also much greater in this species. However, if the presence of interstitial cells has been correctly determined, this offers no ready character for determination, since abraded specimens and even moderately well preserved specimens are scarcely distinguishable by superficial examination in appearance from the last species. The name signifies *large pored or celled.*

Locality and position. Centreville, Soldiers' Home Quarry, Clinton Group.

XXI. Callopora Ohioensis, *sp. n.*

(*Plate* XVI, *Fig.* 6; *Plate* XVII, *Fig.* 17.)

Zoaria more regular in formation than the two species last described, branches varying from 2.5 mm. to 5 mm. in diameter. Cells apparently of two kinds. The true cells are of nearly uniform size, subcircular, and stationed apart at somewhat regular intervals, from 11 to 13 occupying a distance of 3 mm. Separating these cells and usually completely isolating them are a number of interstitial cells very variable in size, even in the same part of the branch, some being larger and some smaller than the true cells, but usually of the same average size. The true cells are usually in our specimens filled more or less with sediment and so are more readily distinguishable. Tangential sections show this feature very plainly. Longitudinal sections do not show any difference in size between the true and the interstitial cells, nor is there any appreciable difference in the number of the straight diaphragms; these features will distinguish it readily from *C. elegantula, Hall.* It will be remembered that only under favorable circumstances was any difference noted in the number of diaphragms in the last species. The number of diaphragms in general is but slightly greater than in that species.

Locality and position. Centreville, Clinton Group.

PLATE XV.

Fig. 1. *Phylloporina angulata, Hall;* the small form for which the name *P. Daytonensis* was suggested by Hall and Whitfield.

Fig. 2. *Hemitrypa Ulrichi, n. sp;* a part of a frond showing the infundibuliform structure.

Fig. 3. *Clathropora frondosa, Hall;* a part of a frond showing the point of articulation with some basal structure.

Fig. 4. *Clathropora Clintonensis, Hall and Whitfield;* fragment of a frond showing a somewhat similar provision for articulation.

Fig. 5. *Ptilodictya expansa, Hall and Whitfield;* a part of a typical frond from Todd's Fork, Clinton County.

Fig. 6. *Phœnopora magna, Hall and Whitfield;* a fragment showing the surface.

Fig. 7. *Phænopora fimbriata, James;* a typical frond, parted along the epithecal membranes; branches frequently found with a looser arrangement.

Fig. 8. *Pachydictya emaciata, n. sp;* the type specimen.

Fig. 9. *Pachydictya bifurcata, (Van Cleve) Hall;* a large frond showing in places a pseudo-anastomosis of the branches.

Fig. 10. *Pachydictya bifurcata, var. instabilis, n. var;* one of the extreme forms.

Fig. 11. *Pachydictya turgida, n.sp,* a typical form.

Fig. 12. *Pachydictya obesa, n. sp;* the basal portion of a frond, its articulating end not discovered; the frond usually widens considerably above and is often decidedly undulating.

Fig. 13. *Rhinopora verrucosa, Hall;* a, a fragment showing raised branching lines; b, a similar specimen in which weathering has caused the same to appear as depressed veins; c, a specimen in which the cells at the junction of the veins have become somewhat more prominent, forming low tubercles.

Fig. 14. *Prasopora parmula, n. sp;* the type specimen.

PLATE XVI.

Fig. 1. *Phænopora platyphylla, James;* a frond, parted along the epithecal membrane.

Fig. 2. *Phænopora magna, Hall and Whitfield;* a frond, parted along the epithecal membrane.

Fig. 3. *Phænopora multifida, (Van Cleve) Hall;* a typical specimen from the collection of Mr. Geo. Caswell; parted along the epithecal membrane.

Fig. 4. *Monotrypella confluens, n. sp;* a, a branch; b, a typical gnarled expansion.

Fig. 5. *Callopora magnopora, n. sp;* a branch.

Fig. 6. *Callopora Ohioensis, n. sp;* a branch,

PLATE XVII.

Fig. 1. *Phylloporina angulata, Hall;* a, celluliferous side; b, non-celluliferous side; c, a tangentitial section.

Fig. 2. *Hemitrypa Ulrichi, n. sp;* a, the network covering the celluliferous side; b, the non-celluliferous side; c, a tangential section.

Fig. 3. *Clathropora frondosa, Hall;* a tangential section.

Fig. 4. *Clathropora Clintonensis, Hall and Whitfield;* a tangential section.

Fig 5. *Ptilodictya expansa, Hall and Whitfield;* a, a part of the surface; b, a tangential section.

Fig. 6. *Phænopora platyphylla, James;* a, a part of the surface; b, a tangential section.

Fig. 7. *Pænopora magna, Hall and Whitfield;* a part of the surface.

Fig. 8. *Pachydictya emaciata, n. sp;* a part of the surface.

Fig. 9. *Pachydictya bifurcata, (Van Cleve) Hall;* a, a part of the surface; b, a tangential section.

Fig. 10. *Lichenalia concentrica, Hall;* a part of the surface, where it has been worn or emacerated, showing the angular intercellular spaces. Copied from Hall, Geol. Surv. Ind. 11th Rep., Plate 5, Fig. 6.

Fig. 11. *Pachydictya turgida, n. sp;* a tangential section.

Fig. 12. *Rhinopora verrucosa, Hall;* a tangential section.

Fig. 13. *Ceramopora expansa, James;* a few cell apertures, as shown by a part of the surface of the type specimens. From a sketch taken from the type specimen in the collection of Dr. L. B. Welch.

Fig. 14. *Prasopora parmula, n. sp;* a, a tangential section; b, a vertical section.

Fig. 15. *Monotropella confluens, n. sp;* a, a part of the surface; b, a tangensial section; c, a vertical section.

Fig. 16. *Callopora magnopora; n. sp;* a, a part of the surface; b, a tangential section; c, a vertical section.

Fig. 17. *Callopora Ohioensis, n. sp;* a, a part of the surface; b, a tangential section; c, a vertical section

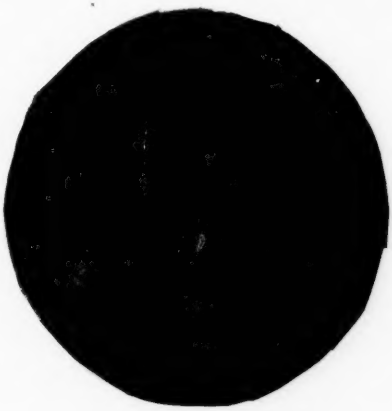


Fig. 1.

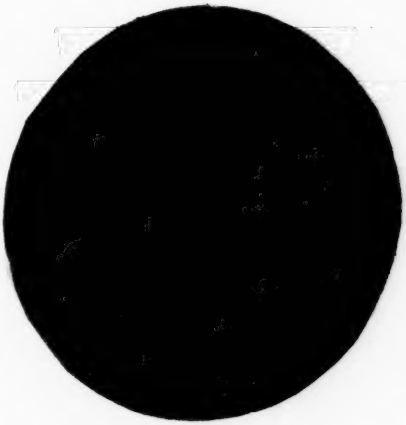


Fig. 2.

PLATE X.

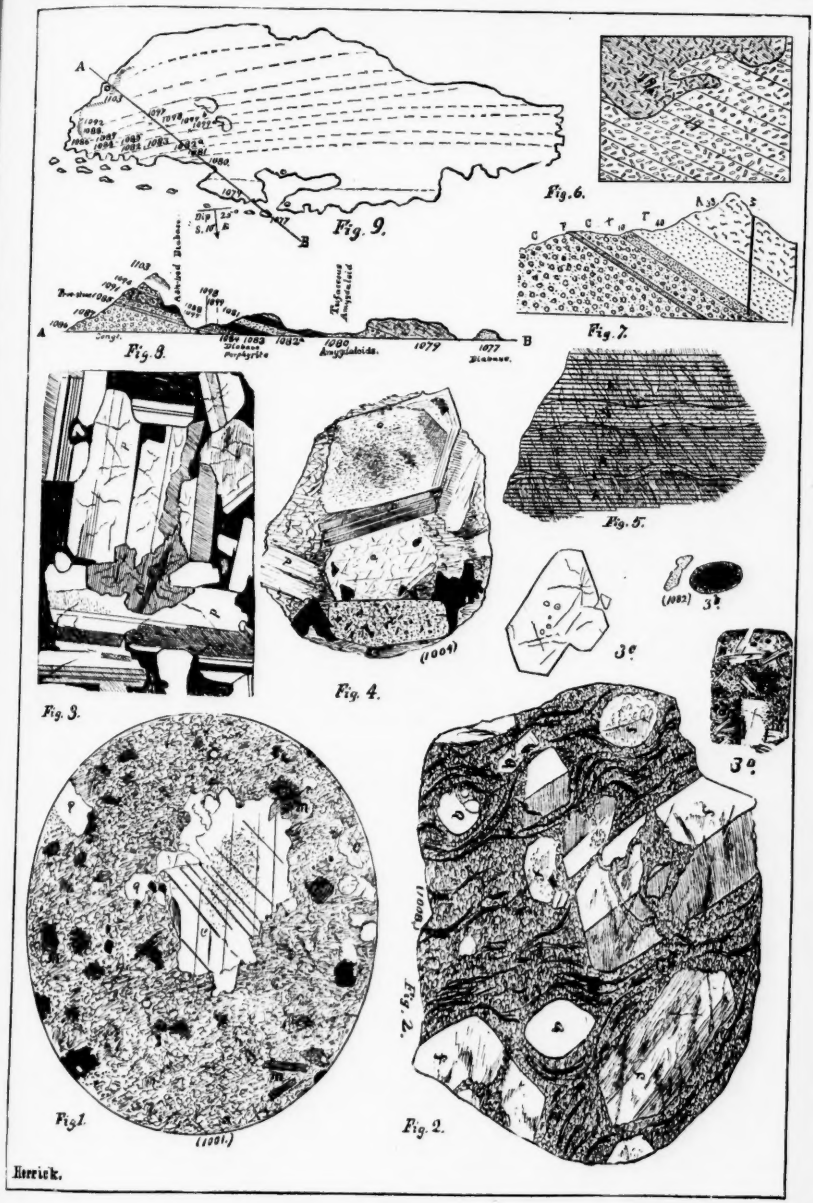


PLATE XI.

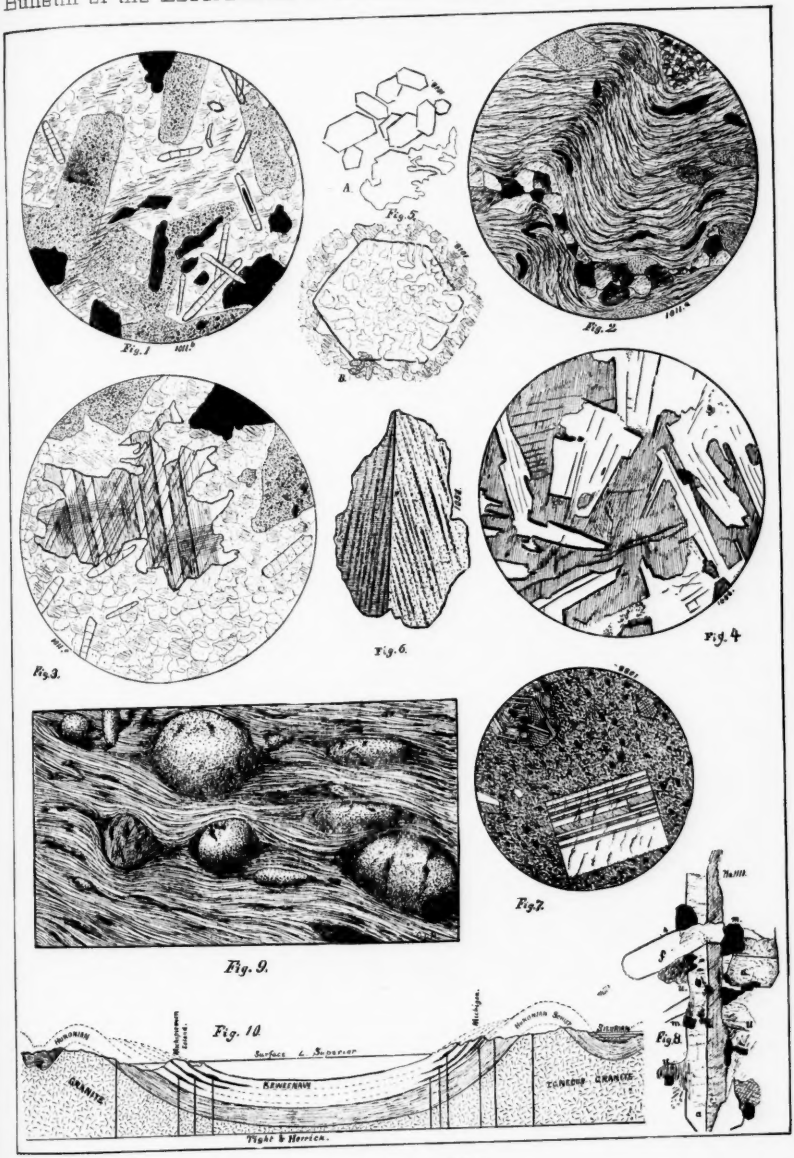


Fig. 1
Fig. 2
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A
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Fig. 6.
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Fig. 8.
Fig. 9.
Fig. 10
Huronian
Granite
Keweenaw
Surface of Subsidence
Michigan
Wisconsin
Illinois
Light & Herrick.

PLATE XII.

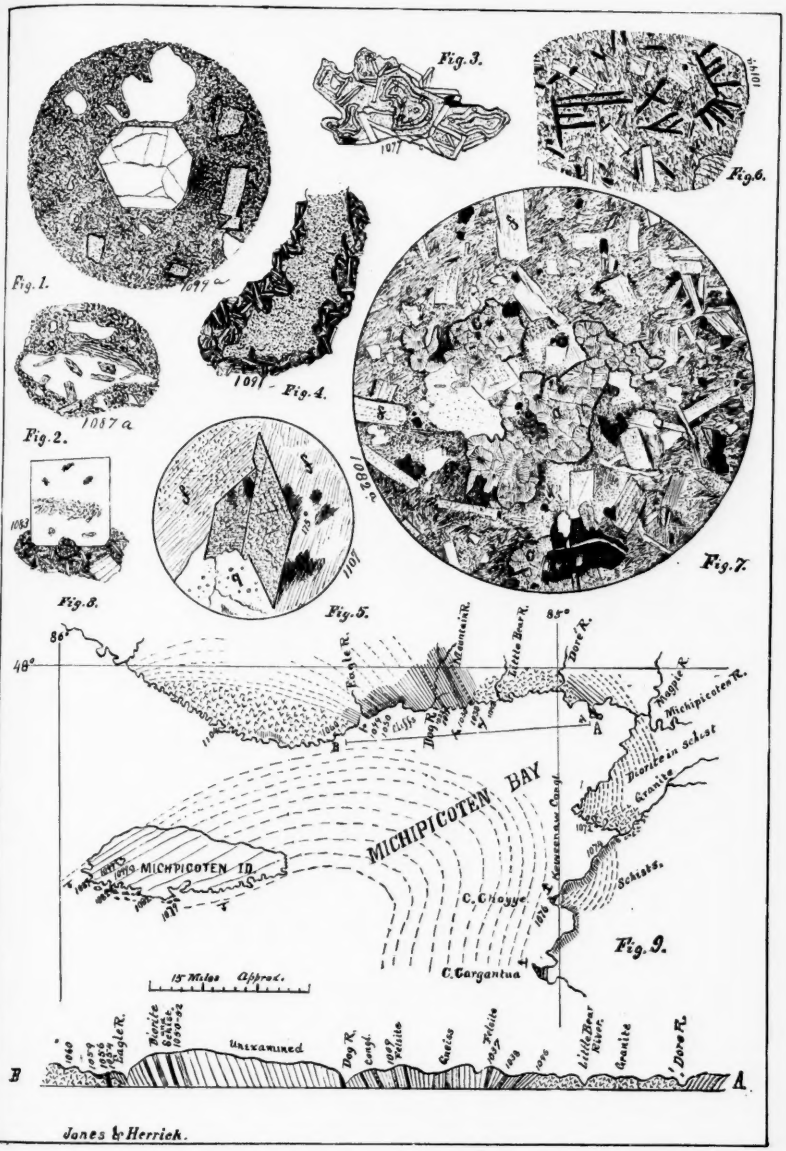
Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.
Fig. 5.
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Fig. 9.
MICHIPICOTEN BAY
MICHIPICOTEN ID.
C. Gargantua
Eagle R.
Dog R.
Little Bear R.
Dore R.
Michipicoten R.
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Schists
Gneiss
Unexamined
15 Miles Approx.
Jones & Herrick.

PLATE XIII.

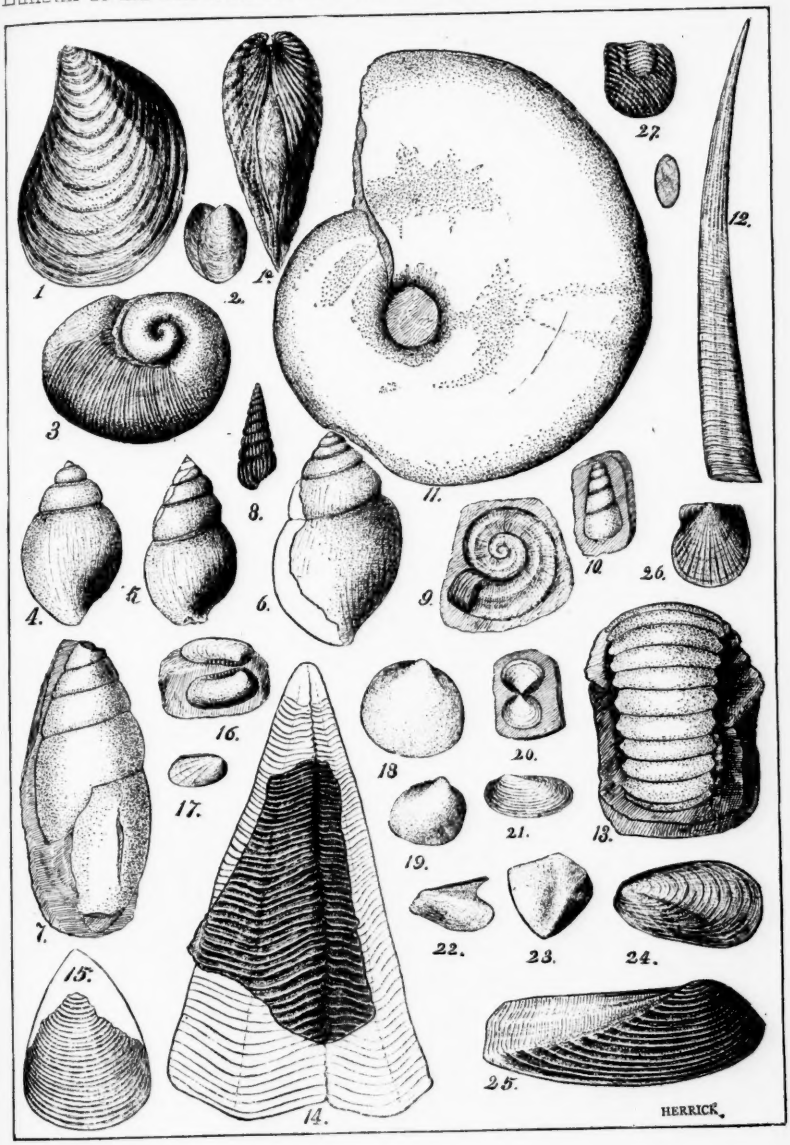
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PLATE XIV.

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